4.4. MODELLING OF CHOICES WITH UNCERTAIN PREFERENCES

4.4.1. Backgrond

People have many occasions in their lives to take actions to avoid or reduce risks. In order not to spend all their resources on risk avoidance, they implicitly consider what the value of risk reduction is, and they try with more or less success to carry risk avoidance only to a point justified by the costs. This point is often unconscious or subconscious. It is carried out imperfectly and is beset by lack of information due to the fact that, while the events to be avoided involve very great values, the probabilities are small and outside the realm of everyday experience. Knowledge about risks is important. This is particularly the case for environmental risks. Thus people tend not to know their own minds on the subject of risks. Section 4.4 addresses the problem of making choices about risky alternatives in view of knowledge imperfections. Section 4.4.2 introduces the difficulties for benefit-cost analysis caused by risk, and the approach taken to solve them. Section 4.4.3 discusses relevant issues in the theory of expected utility. Section 4.4.4. introduces the concept of uncertain preferences. Section 4.4.5 critiques the literature on risk from psychology and relates the concept of uncertain preferences to the economic literature of behavior towards risk. Following introductory comments in section 4.4.6, section 4.4.7 and 4.4.8 produce a series of theorems that indicate how people process information and make choices about low probability events on the basis of the results. Section 4.4.9 compares the effects of using comparison questions versus. reraling questions. Section 4.4.10 introduces the realistic assumption that respondents' answers to certain questions are interrelated, and examines its implications. Sections 4.4.11 through 4.4.13 discuss the effects of limited memory and bias in the answering of questions about risky events. Section 4.4.14 draws implications of the theorems for the study of serious illness, giving particular attention to contingent valuation.

4.4.2. Apprpach Taken in This Section

A major benefit of air pollution regulations is the reduction in health risks. If the govenrment wishes responsibly to decide on the correct level of standards to impose, it must attempt to determine what value individuals place on health risk reduction. Ultimately there are only two ways to gain this information. One is to observe market behavior and, through the logic of revealed preference, to make inferences about individuals' tastes. The other is to ask individuals directly

about their preferences. In the case of most public goods, including air quality, there are few markets in which individuals can reveal their preferences--indeed, this scarcity of markets is the reason government must be concerned with the problem in the first place. Thus it appears that surveys and interviews are likely to be necessary in any attempt to assess the public's demand for reduction in health risks.

Researchers have, however, run into serious difficulties when they have attempted to interpret individuals' responses to questions about their preferences in risky situations. Many economists are suspicious of survey responses about willingness to pay, feeling that they are subject to strategic manipulation by the respondents. In the case of survey data on risk tolerance, there are much more immediate problems: Answers elicited appear to be at odds with the standard economic theories of risk aversion. Worse, they appear to be inconsistent with the fundamental assumptions of rational decision making.

Therefore, to be able to use survey data to establish the value of the benefits from risk reduction, we need a framework that will enable us to interpret that data consistently in a cost-benefit analysis. Section 4.4 will attempt to provide the conceptual basis for such a framework. The framework we propose is one in which it is costly for individuals to determine their own preferences and therefore unlikely that their responses to survey questions will reflect their true choices with absolute accuracy. We will demonstrate how cost-benefit analysis can be interpreted in such an environment and briefly indicate some implications for the handling of surveys of individuals' risk tolerance.

This approach is consistent with much recent work in cognitive psychology, and can in fact be understood as a economic reinterpretation of some of that field's analysis. It differs, however, from the approach taken by much recent work in economic theory. We will begin therefore by outlining the recent theoretical alternatives to expected utility, the reasons why they have been advocated, and the reasons why we feel these approaches are not adequate to handle the problems inherent in the use of surveys. Then we analyze the conceptual problems with cost-benefit analysis when individuals are uncertain about their own preferences, and the limitations of and uses of surveys in those circumstances, Next we briefly review psychological models of decision making of relevance to our problem. Finally, we develop a model of uncertain preferences which translates the psychological models into a cost-benefit framework. We use the structure briefly to examine the methods by which surveys may most effectively be used to gather information about the true underlying preferences.

4.4.3. Expected Utility Theory and Its Critics

For more than two decades expected utility theory has been the dominant paradigm in economics for modeling individual decision making under uncertainty. The main appeal of the formulation has been theoretical; the axioms from which the expected utility theorem is derived are simple, elegant, and for the most part intuitively unobjectionable. The framework has proved to be a solid foundation on which to develop both macroeconomic and microeconomic theories, and to be a handy and reliable maintained hypothesis in empirical work examining markets in which uncertainty was a consideration.

While the theory has been dominant, it has not been without objections and challenges, both on theoretical and empirical grounds. The theoretical objections have centered on the so-called independence axiom. The independence axiom, as illustrated in figure 4-4, says that lottery A is preferred to lottery B if and only if a compound lottery in which A is the prize with probability p and C is the prize with probability (1-p) is preferred to a lottery in which B is the prize with probability p and C is the prize with probability (l-p), for all A, B, C and p. Although this assumption seems a priori reasonable, it is not as fundamental as the other axioms upon which expected utility theory is based. The main objections to it have arisen from empirical results in which individuals' stated preferences appear to violate this axiom. Among the earliest examples of this violation are those by Allais (1953).

A simple version of the phenomenon noted by Allais can be described as follows.. In Figure 4-5 virtually all individuals of moderate income prefer $10,000 with certainty (call this outcome A) to a 50 percent chance at $30,000 (and a 50 percent chance of receiving nothing. Call this lottery B). On the other hand, as illustrated in Figure 4-6, many individuals prefer a .001 percent chance at $30,000 (call this X) to a .002 percent chance at $10,000 (call this Y). Holding to both of these announced preferences violates expected utility theory. To show this it is only necessary to realize the the distribution of outcomes in lottery X is equivalent to the distribution in a compound lottery where at the first stage there is a .002 percent chance of winning, where the prize is a ticket to lottery B, while lottery Y is a compound lottery in which there is a .002 percent chance of winning the prize, which is a ticket to A.

Allais cited the independence axiom as the weak link in the chain and called for its abondonment. Striking as examples of this form were, they had little effect on-the mainstream of economics, because Allais built no coherent theoretical structure to set as a rival to expected utility theory. The first completely developed analysis which dropped the independence axiom is by Machine (1982), who also surveys the empirical

Figure 4-4. INDEPENDENCE AXIOM

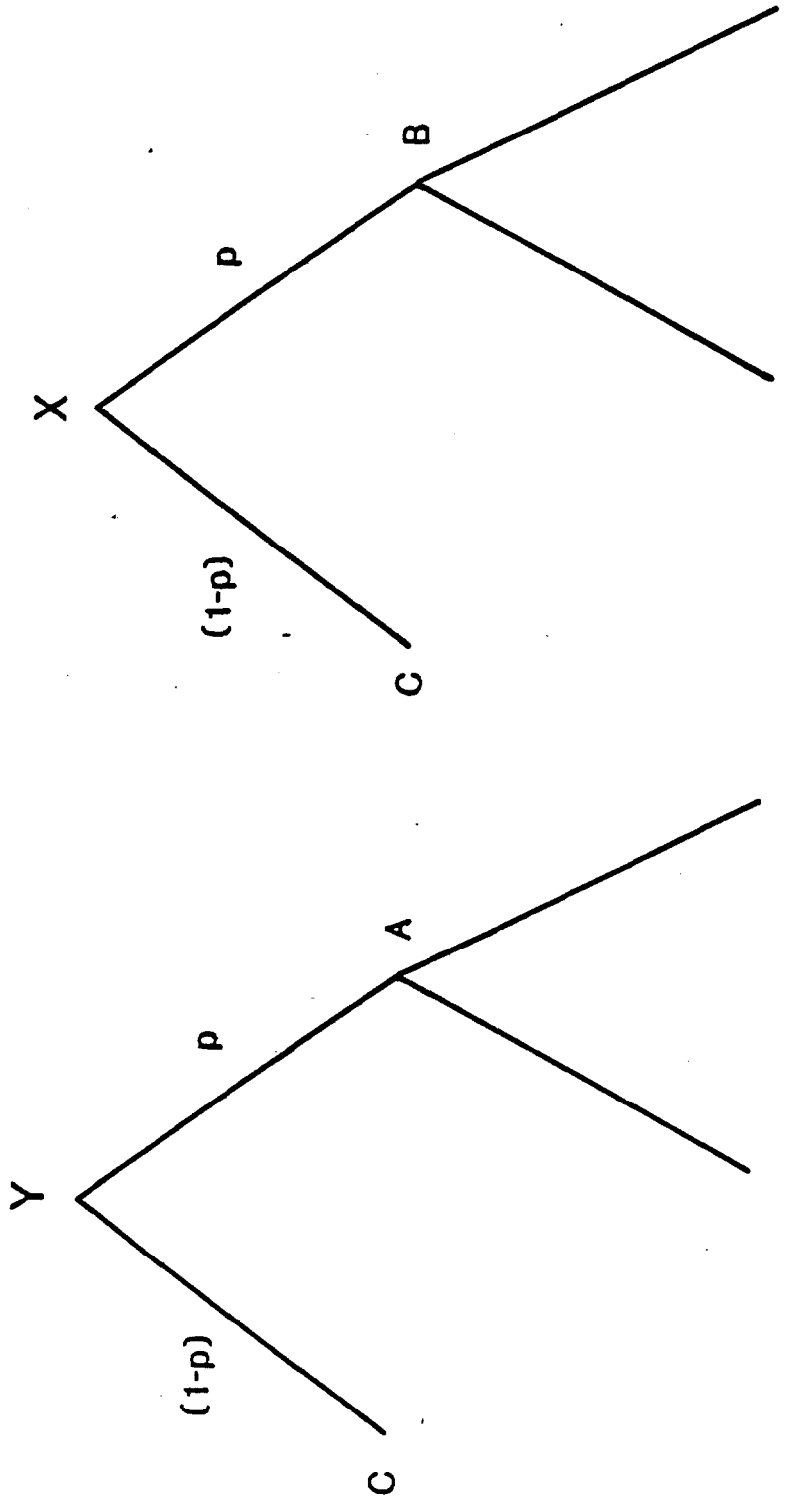


Figure 4-5. **ALLAIS** PARADOX (A)

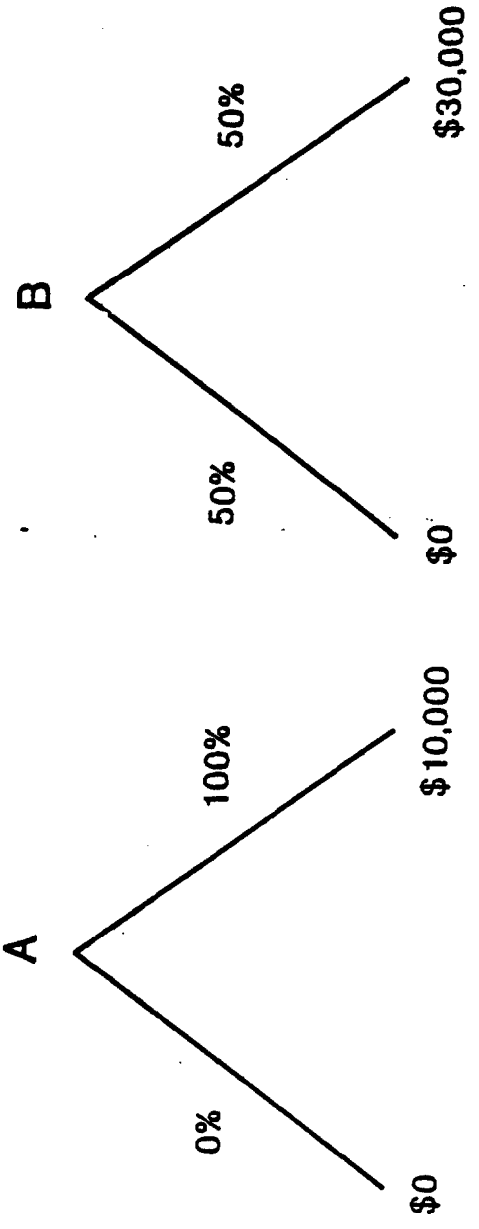
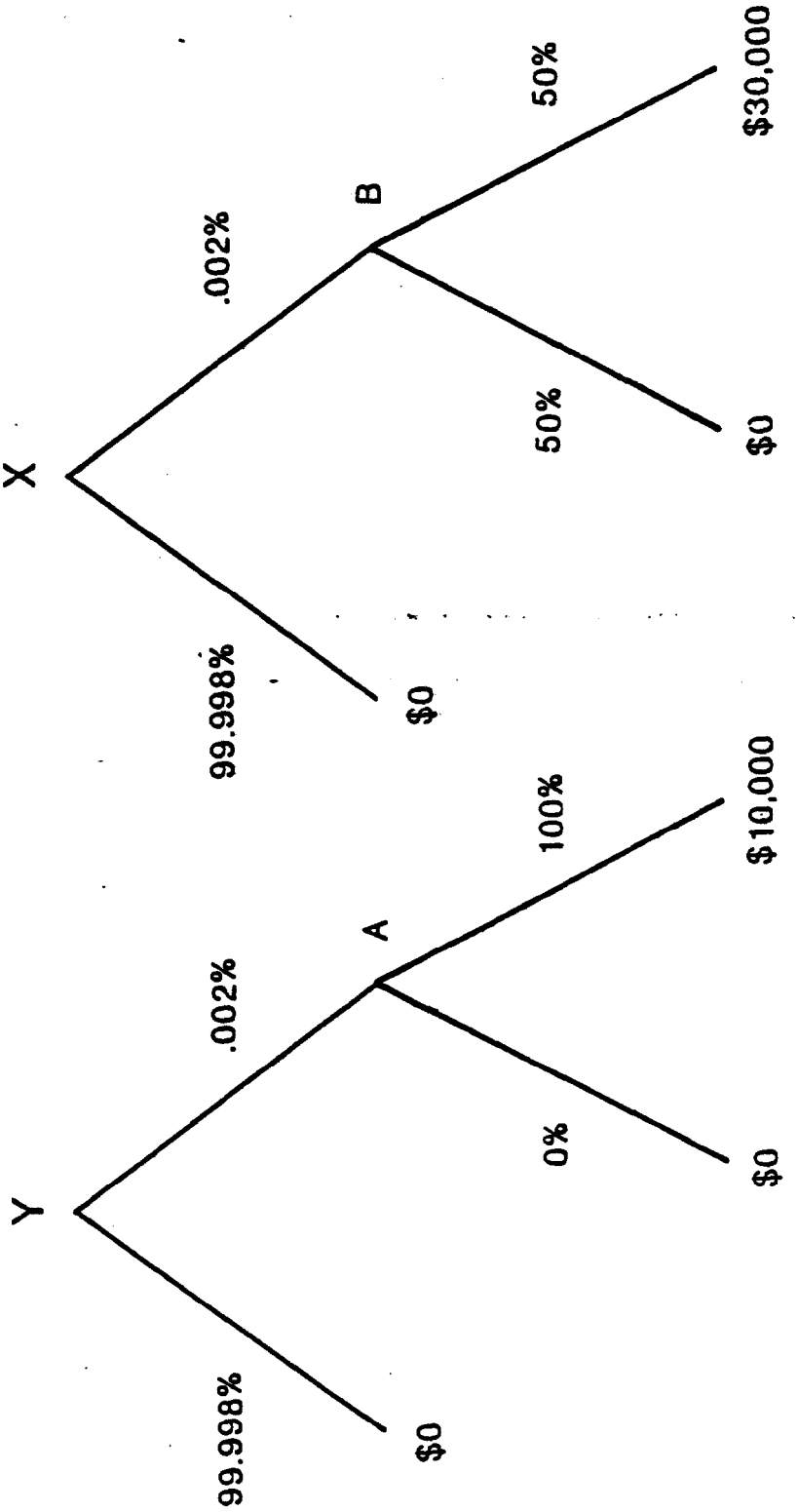


Figure 4-6. **ALLAIS** PARADOX (B)



objections to expected utility and indicates which of them his extended theory can address.

Machina analyses the extension of expected utility theory results when the independence axiom is replaced with the **less-** restrictive assumption that preferences are smooth in changes in gambles. He demonstrates that expected utility theory still holds as a local approximation describing individuals' tastes for relatively small changes in gambles around a (possibly random) initial wealth level. Any properties which we wished to attribute to expected utility functions, for example declining risk aversion, or regions of relative risk loving, can now be attributed to the so-called "local utility functions" at various initial wealth levels. This is valuable for it permits us to rationalize not only the **Allais** paradox, but also the observation by Markowitz **(1952)**, that individuals continue to buy both insurance and lottery tickets as their wealth changes. Expected utility theory can rationalize purchases of each by postulating regions of risk aversion at levels of wealth below the initial wealth, and regions of risklovingat levels ofwealthabove the initial wealth. However, as the **individual's** wealth changes, and he moves out of the initial boundary level between these two regions, one sort of behavior or the other should be abandoned according to the simple theory, and this does not appear to happen. **Machina** resolves the problem by appeal to variations in the local **utility function** as the individual's wealth changes.

A similar type of analysis can rationalize the **Allais** paradoxes: the local utility function is again not independent of the entire set of outcomes available to the individual at the time the decision is made. Thus there is nothing unexpected in the fact that the existence of a chance at C affecting the preferences for A versus B.

However, as **Machina** himself notes, there are several observations in the experimental work on risk preferences that cannot be squared with expected utility theory even when extended in the **Machina** manner. Most of these are violations, not of the independence axiom, but of the assumption that preferences are dependent only on the distribution of outcomes that the lottery yields, not the form in which the lotteries are presented. In the language of psychology, stated preferences appear to depend on the context in which the alternatives are "framed."

A striking example of this phenomenon appears in the work of Kahneman and Tversky (1979). They build examples in which preferences are altered when initial wealth is increased by **a** fixed amount, and the outcome of the gambles offered is decreased by the same amount in all realizations. Note therefore that the assumption that is being violated is an extremely basic one. namely, that preferences depend only on the final distribution of outcomes. Another, equally basic situation of inconsistency of preferences is described in the work by Grether and Plott (1979). who trace the evidence of their particular "preference reversal

phenomenon" through several experimenters' works. This phenomenon is the fact that individuals, when asked to state a certainty equivalent for a 'gamble, will often choose a value which is greater than the dollar value they will in fact choose in preference to that same lottery. That is, given a lottery A, an individual will claim that he is indifferent between A and some dollar payoff D, and then in fact if offered a choice between A and some lower payoff L, choose L. This observation apparently violates no less an assumption than the transitivity of preferences; no extension of "expected utility" theory can adqequately handle it, and in their survey Grether and Plott conclude that the explanation must lie in. some sort of information processing problem.

However, once we have decided that it will be necessary to include the difficulties of information processing as part of our modeling of the decisions made by individuals facing risk, then these same difficulties can be used to explain the other phenomena which the dropping of the independence assumption was intended to address (see below). Nor is the dropping of the independence assumption without cost. Observers have generally agreed as to the normative **disirability** of the independence assumption. If we are trying to develop a framework for **cost-benefit** analysis, these normative arguments carry considerable weight. For if we drop the independence assumption we will be faced with a certain time-inconsistency in our subjects' preferences over lotteries. While there is nothing **self-contradictory** in this fact, we will then discover that we can change individuals' welfare simply by restricting their ability to change their minds about which choices they will make,

For instance, suppose we use the lotteries described in figure 4-6. Suppose we start by only allowing the individual lottery B in the event that the .002 percent chance arises. Then before the outcome of this chance, the individual's utility is equal to the utility associated with lottery X. Now suppose we expand the choices available to include the choice either of lottery B or lottery A in the event that the chance arises. The result is a decrease in the individual's current utility from X to Y. The individual's reasoning against the **increase** in his choice set is as follows: "Should the chance arise I know I will pick lottery A, because as of that date I will prefer it to lottery B, but in fact, from my current perspective I prefer lottery A to lottery B, thus my utility has decreased by my not being able to prevent myself from picking this **currently-less-desirable** alternative."

Another recently revived alternative to expected utility--regret theory--generates similar difficulties. This alternative theory assumes that the individual decision maker makes choices based not on the distribution of outcomes, but on the distribution of the **difference** between the chosen outcome and the outcome not chosen. This approach, based in **minimax** strategy game theory, was a popular early rival to expected utility theory, and it has recently been advocated by Loomes and Sugden. A major

difficulty with the theory is that it implies an intransitivity of preferences, since individual preferences are not independent of the set from which the choices are made. The authors of the article argue eloquently that there is nothing "irrational" about such a model of behavior, nor is there any logical inconsistency in the structure. Although this is true, allowing this assumption does equal damage to the welfare analysis. For if we let the government expand the set of available choices we again find that utility can decrease, as individuals choose less preferred alternatives because of the intrusion of seemingly irrelevant alternatives.

In short, it appears to us that the price in terms of difficulties with welfare analysis is too high to pay, especially given the less drastic modifications that can be made to rationalize the observed responses to risk surveys and still maintain the fundamental welfare-economics structure intact.

4.4.4. Conceptual Problems with Welfare Analysis When Tastes Are Uncertain

Thus we conclude that the best way to procede in trying to interpret surveys of individuals' attitudes towards risk is to retain the independence axiom but admit that individuals do not know their own tastes with certainty. There should be nothing counterintuitive in this position: Most people do not deal regularly with issues of risk; most people therefore are not likely to be very expert in stating their preferences over risky alternatives. Under the circumstances, it is not surprising that when presented with a complicated set of alternatives among which to choose, most people make choices thatseemto implythattheir preferences are intransitive. However, we would expect the same thing to happen if we presented real world consumers with multivariate bundles of goods and asked them to choose among them. As long as we kept the bundles the same in most dimensions and only varied a few at a time, we might have reasonable hope to obtain a consistent ranking. But when we ask individuals to rank among pairs of highly dissimilar bundles, we would not be surprised to find apparent inconsistencies in their preferences. Individuals are likely to make mistakes, and to be subject to the utility-equivalent of "optical illusions" when describing their preferences.

The crucial test is the subject's reaction if confronted with the apparent inconsistency of some set of preferences. Suppose we say to a particular individual after an interview "you have said you prefer A to B, you prefer B to C and you prefer C to A. Do you see any inconsistency in these statements?" If the individual's answer is "yes, upon reflection I prefer A to C: we are home free. If his answer is "yes, I see a problem there, but I cannot tell which of my statements are incorrect." Then we too have a problem, since the decision task is so difficult for the individual that he cannot straighten out his preferences even

upon reflection. Nonetheless, our hypothesis of consistency of preferences is still intact. Only if the individual says "no, I see no problem at all with those statements" are we in deep trouble, for then the individual must mean by the word "preferences" something quite different from what we mean by the word. In the case of Grether and Plott's preference reversal phenomenon it is extremely likely that if confronted with the apparent contradictions in their statements the subjects would agree that their preferences would need revision. It is less clear from the evidence that this is the case in the Allais paradox cases. But at least in multiattribute problems, descriptions of individuals' decison making processes seem to indicate that transitivity of preferences are an underlying assumption in their own actions (Payne et al.).

To summarize, our position is the following: if individuals do not have consistent preferences and deny that their own preferences need be consistent, we cannot do welfare economics. If preferences are asserted by individuals to be consistent then there is at least the possibility that progress can be made. However, given we can no longer assume that individuals know their preferences, the question remains, "what is the correct set of criteria for making welfare judgments?"

One approach is to argue that the correct criterion is the criterion that would be used by the politician hoping for reelection. Voters make their decisions as to whom to reelect without being forced carfully to think through their casually stated preferences. If they do not know what their preferences would be if they had thought through the situation sufficiently, it is of no concern to the politician--those "true" preferences must be irrelevant for reelection. If that means that different preferences might be elicited by stating the decision problem in different ways, then so be it; we must state the decison problem in the form that the politician in power chooses to state it, and then record the answers as accurately as possible.

The drawbacks of this point of view are obvious. Presumably if the approach were explained to any voter, he would prefer that alternative criteria be adopted by the investigator. One alternative appraoch is the following: the problem stems from the difficulty in eliciting individual preferences--this is always a costly matter, as polling organizations insist. It is particularly difficult if individuals themselves find it costly to determine their own preferences. Under the circumstances, a voter might prefer that the investigator use more extended surveys, spending sufficient time and resources with each indivdiual interviewed. Care should be exercised by going through the initially stated preferences of the individual in sufficient detail to determine if there are any inconsistencies in them, by double checking those inconsistencies with the individual, by presenting the decision problem in several different formulations to double check that the individual is not being swayed by illusions of the presentaiton, and finally by giving the individual sufficient practice at answering decision

problems of the sort we are dealing with to allow him to train himself in determining his own preferences.

This approach, if explained to the average voter, would presumably draw greater support than the initial one. Even if the voter himself is not picked for the interview, if he regards himself as sufficiently typical in his tastes, he will prefer having a proxy go through this more extensive interview to get at what his own true preferences are likely to be. Nonetheless the average voter is still likely to have reservations about this procedure. The extensive interviewing is largely a matter of "education." From the investigator's point of view, it is the individual educating himself about his own preferences. From the point of view of a suspicious outsider, it could easily be the interviewer educating the subject as to what his preferences should be. These suspicions are likely to be particularly strong if the conclusions of the investigation go against the surface preference of the outside observer. In short, the procedure must be carefully tailored to ensure that there is no presumption as to what are the "right" or "wrong" preferences in the situation--beyond the basic requirement of transitivity.

This is particularly difficult to achieve since people will be dealing with questions to which moral strictures are commonly placed. Many people believe gambling to be morally wrong, and maintenance of health at all costs morally correct. In assessing the value to one individual of another individual's health, moral perceptions will play even greater a role. One way of characterizing the difficulty is to describe an individual as having two sets of preferences--the preferences of his "selfish self" and the preferences of his "socially conscious self"-- and then trying to decide, not which preferences actually count in individual decision making, but which should count for welfare analysis. Another, probably more fruitful way of describing the situation is to say that individuals' stated preferences depend on their audience. Many of the causes of this dependence can be reduced to a desire for various sorts of approval--desire to appear to be a sophisticate, a moral individual, a member of the team. Nonetheless, we do not need to distinguish between the various reasons for stated preferences to vary. Our operational definition of "true" preferences is those that would dominate in the privacy of one's own home-- or in the privacy of the voting booth. It still then is an open question as to whether the normative standard ought to be the sum of individuals' private preferences but as a practical matter it should not be surprising to find that indivdiuals will report different preferences to an interviewer than they will declare to friends or through their actions. Although this difficulty of moral overtones on prferences is not a primary focus of this work, it is a problem which will inevitably arise in the interviewing procedure. Ultimately there is probably no resolution of the issue and the only procedure open to the investigator will be an examinaton of the extent to which individual preferences are influenced by the groups in which they find themselves during the interview.

4.4.5. Psychological Studies

Cognitive psychologists have not been concerned with the ethical/public policy question of which statements of preferences should be taken into account in the determination of public policy. On the other hand, they have studied much more carefully the question of what structures we can use to model preferences which underlie the apparently inconsistent choices individuals make.

An early version of a formulation which allows for inconsistent answers to choice questions is the random utility model (Thurstone), which in effect posits the existence of a distribution over possible consistent underlying preferences, and then assumes that each question is answered with respect to a draw from one of the distributions. Note that the random utility model is not, easily reconciled with economic models of decision making. For instance, it is not equivalent to a model in which the consumer has Bayesian priors about his own preferences. Such an account would instead yield a more complicated, but still perfectly consistent set of preferences over lotteries--indeed the structure could be aggregated into a state preference model in the ordinary way,

The assumption underlying the Thurstone model is that there is a difference between the purely intellectual question "which do you like better?" and the economic question, "which will you take?" (compare Little). The random utility model simply assumes that over time an individual's preferences change randomly so that the answer can vary stochastically' to the question when repeated. An alternative formulation, and one much more useful from our point of view, is that the underlying preferences are constant but the structure by which these preferences are translated into 'decisions is stochastic (Luce, Tversky). There has been much concern in that literature with the equivalences or non-equivalences between various formulations of the random utility model. For our purposes, however, the issues are two: what rational calculus can underly such a model and what implications will it have for welfare economics? Our job as economists is to delve through the stochastic portion to the underlying preferences; our task in a survey then is to minimize the noisiness of the response, and it therefore becomes important to understand where the noisiness comes from.

This investigation belongs to the subfield of psychology known as decision research. Its investigation involves several methohologies not normally used in economics, including such techniques as "verbal protocols" (the investigation of subjects' reports of their own behavior) and records of subjects' use of information in the decision process (Payne et al.). A useful distinction made in this field is between decision making based on alternative ranking versus decison making based on attribute rankings. Alternative'ranking involves the process normallv treated in economics--all alternatives are measured in some

common scaling and the highest of these scalings indicates the preferred alternative1 In, attribute processes the various attributes attached to the alternatives are ranked and then these rankings in various dimensions are compared to determine an overall ranking. The latter is useful when the tradeoffs between the different attributes are difficult for the individual to determine, but the cost is that such systems of decision making easily result in intransitive rankings. Various authors in this literature have focused on various procedures by which attribute rankings are accomplished (a brief survey is included in Aschenbrenner). Kahneman and Tversky focus on the various considerations that arise in the process of decision making in complicated situations.

Among them are the "isolation" phenomenon and the "anchoring" phenomenon. By "isolation" is meant the focusing on the aspects that are perceived as the main contrasts between the two available alternatives, treating as precisely equal the aspects perceived as of smaller difference. Thus the Allais paradox can be explained as an approximation'error due to the decision maker's initial estimate that there is relatively little difference between probabilities of .002 and .001 as opposed to differences between outcomes of $10,000 and $30,000. The phenomenon of "anchoring" is a perceptual dependence on initial conditions, a tendency to estimate values as closer to values already examined. Grether and Plott's preference reversal can then be rationalized as a tendency for certainty equivalents to be anchored to the winning payoff in a gamble.

Thus it would appear that the phenomena most likely to pose problems in interpreting surveys of risk preferences can be understood without abandoning the independence assumption. Our job is then to provide an economic basis which can rationalize the use of such structures.

4.4.6. Components of an Economic Model

The basic component of the model is a set of prior preferences', which describe the individual's beliefs about his own tastes in the event that he makes no expenditures to examine those tastes.

The individual can also expend an amount of psychic costs to improve the sample of his tastes. The expenditure gives him a draw as to his own tastes, which in conjunction with his priors can be used to derive new tastes. Each new draw can be added to the set.

We then need memory to store the draws. The simplest story is that memory is infinite, so that each draw is stored and we can at any point find the set of consistent preferences representing an individual's beliefs at that point. The more difficult, but possibly more interesting model, has finite memory, so that after some point more draws can only be added by

dropping the information in earlier draws.

The next step is to allow degrees of investment in reducing the uncertainty over the prior preferences. Greater investment entails a greater psychic cost, but allows a sharper prediction as to preferences. Given previously learned information we can imagine the individual as choosing to think more or less carefully in attempting to answer the latest question. This is a useful distinction for understanding the problems of "anchoring," since individuals' initial response will make it worthwhile not to spend as much energy in attempting to answer subsequent questions, relying instead on the initial answers to provide clues. It also has testible implications in the case where memory is limited, since the anchoring should diminish as the length of time between related questions on the survey increases.

So far we have not discussed the role of the closeness of one outcome to another. To do so requires the addition of a metric to the problem, which metric describes the "similarity" between outcomes, and therefore the degree to which the guess on one outcome affects the likelihood of responses on other outcomes. Once this metric is established it becomes useful to describe the situation where different questions elicit different sorts of investments in introspection, some being more useful to anwering one, and some to answering another question.

Finally, we will drop the assumption of unbiased estimating by the decision maker, and consider the effects of limited forms of bias on the outcomes. This last modification will be necessary to understand preference reversals due to "framing."

4.4.7. Formal Model Statement

Suppose that there are I alternatives being considered, each with an unknown utility U_i. Let U be the vector of these utilities, and let F(U) be the joint probability distribution over U. To begin with we will take the U_i to be i.i.d. Throughout the the paper our examples will assume that the U_i's vary normally and independently, with prior means m_i and precisions h_i (i.e. l/variance).

The individual can, by spending a psychic cost of k, receive extra information about his true preferences. We assume that the extra information gained by this "introspection" is a draw of two random variables which are estimates of U_i and U_j which we call V_i and V_j respectively. We assume

$$V_i = U_i + e_i,$$

where e_i is measurement error which in our examples we will assume is distributed as a normal with mean 0 and precision g_i, and independent of all other errors e and of all U_i's (and similarly for the distribution V_j).

Given any string of information $(V_1, V_2, \ldots) = S$, we can derive posterior distributions of the utilities of the alternatives $F(U|S)$. In the case of normal distributions, a simple application of Bayes's rule shows that, given a draw of V_i, the posterior distribution of U_i is normal with mean

$$m_i^*(V_i) = (m_i h_i + v_i g_i)/(h_i + g_i)$$

and precision

$$h_i + g_i.$$

If no draw is made, the individual's expected utility if given a choice between U_1 and U_2 is

$$\max (m_1, m_2).$$

If the draw is made, utility is

$$\max ((m_1^*(V_1), m_2^*(V_2)) - k).$$

The first model we will consider is to solve the following Bayesian decision problem: The individual is presented with a series of alternatives, where each alternative is a pair of outcomes, one of which he will receive. He is asked to make his choice. For simplicity we will assume that at each instant he treats the question being asked him as the last problem he will face. (In fact, the problem is more complicated since an individual might be expected to anticipate that a series of questions will occur and modify his introspection accordingly. We will ignore this refinement. If the reader wishes, he can assume that the survey is structured so that at each stage there is an extremely low probability of any one participant's receiving an additional question. This makes it possible to ignore the likelihood of extra questions at every stage.)

The decision problem for the individual, namely how many draws to invest in, can be formulated either sequentially or non-sequentially. These formulations mirror the strategies analyzed in the research literature. The non-sequential formulation (Stigler, 1961) has the individual precommit to a fixed number of introspections. The sequential formulation (Kohn and Shavell, 1974) allows the individual at every step to consider further expenditure on introspection based on the results he has learned so far. Although the specific optimal strategies differ between these two formulations, the general outlines are similar. Since

our problem is a specific version of the search problem, we will consider ourselves free to switch back and forth between the two formulations in the examples that follow, depending on which yields the more tractable analysis in any specific application.

In this structure. it will not generally be optimal for the individual to eliminate all uncertainty about his own tastes -- indeed it will not generally be possible. It can be shown that:

Theorem 4-1: Less information is acquired

1> The greater the difference between prior estimates of the m_i's.

2) The lower the variance of the prior estimate of either U_i.

3) The greater the variance of the noise in any estimate.

4) The greater the cost of information acquisition.

On the other hand, the posterior announced preferences are more accurate

1) The greater the difference between prior estimates of of the m_i's.

2) The lower the variance of the prior estimate of either U_i.

3) The lower the variance of the noise of any estimate.

4) The lower the cost of the acquisition of information.

In actual experiments, it is often the case that instead of receiving the payoff with certainty, the subject only receives it with some probability less than one. For this modification we have:

Theorem 4-2: When the probability of actually receiving the payoff decreases, subjects

1) expend less effort in determining their own tastes, and

2) give less accurate ex post predictions of those tastes.

These conclusions are immediate from the model, but they do lead to some natural considerations for survey design: Difficult questions will simply not be given much consideration. Questions which yield potentially great payoffs in that it is costly to answer incorrectly will be given more consideration, but ex post are still likely to lead to inaccurate answers. Questions which

the individual considers easy to answer ex ante will not be given much additional consideration by the individual.

Next we consider the effects of the answer to one question on the answer to subsequent questions. Note that in this model, repeating the same question several times in succession yields no new information, since the individual has already optimized and thus has no reason to make further introspections. However it turns out that expending information on answers to one question will, in general, yield information useful to answers to other questions.

Suppose we ask the individual about a completely new pair of alternatives. In the model in which all alternatives have independent distributions, previous introspection has thrown no light on his preferences with regard to these new alternatives. Thus his behavior is the same as if the questions had never been asked. However, consider the case where the second question gives us as an alternative one of the options already considered in the first question. Now previously gathered information becomes useful and the subjects' responses will be affected.

There are two considerations. First, having answered one question already means that the answer to the second question will start from a more accurate assessment of the beliefs than would otherwise be obtained. This decreases the likelihood of extra investment but increases the expected accuracy of the ex post announced choice.

The second consideration depends on the realizations actually obtained in response to the first question. If the realization causes expected values of the two alternatives in the second question to move further apart, then the likelihood is that there will be less investment in examining the second question. However, if the realizations bring the values of the two alternatives closer together, then investment in answering the second question will tend to increase. On average, these two possibilities balance and we have the first. consideration dominating. Therefore although the presence of preceding related questions on a survey may in any instance increase or decrease the amount of investment used in determining the answer to subsequent questions, we can nevertheless conclude that:

Theorem 4-3: Expenditure on introspection on average decreases through the survey, while accuracy increases.

'Among other things, this result predicts a decline over time in the attention paid by respondents to questions within a survey-- a tendency often observed--without needing to postulate a fatigue factor.

More generally this interrelationship will be observed in any model in which answers to one question help answer another We will consider in more detail below the case where priors for

various alternatives are no longer independent. But the phenomenon can occur when priors are independent as long as there is some dependency in the'sampling. The example of this discussed above is the simplest one. Another case occurs when introspection reveals information not about the 'two alternatives independently, but only about the difference between their values

$$U_j - U_i + e$$

(We will call this the case of "Sampling of differences.") In this case, whenever we find that an individual indicates that i is preferred to j, it means that we can expect that i has a higher value than initially anticipated, and therefore is more likely to be preferred to other alternatives as well, and conversely for j. Thus even in the case of independent valuations, a primitive form of anchoring emerges.

4.4.8. Answering a Series of Questions

Given this structure,. there will be nothing paradoxical about 'a sequence of answers to questions leading to apparent intransitivities; it will simply be the case that between answers additional information has been derived. It will also be perfectly possible for individuals to reverse their answers on subsequent repetitions of a question, provided that other questions have intervened which have led the individual to seek more information.

Suppose we now consider asking a third question and that there are only the three alternatives U_1, U_2, U_3 under consideration. If preferences are perfectly known, then the entirety of the information can always be revealed with three questions, and often with two. If preferences can only be determined with a cost, there may be a gain from asking an apparently redundant question. In our model we have:

Theorem 4-4: Suppose the first question determines that U_1 is preferred to U_2 and the second question determines that U_2 is preferred to U_3. Then

1) In response to the third question "Do you prefer U_3 to U_1?" there is a finite possibility of the answer exhibiting an apparent intransitivity.

2) In response to the third question "Do you prefer U_2 to U_1?" there is a finite probability of the answer exhibiting a reversal of preferences.

In any case, later answers are more likely to reflect true preferences than are early answers in the list.

Theorem 4-5: Suppose furthermore, that we continue to cycle through the questions in the same order indefinitely. Then the probability is zero that there is no number n such that for all questions beyond the nth no further investment in introspection is made. In order words, responses eventually settle down and preference reversal ceases. Moreover, at the point where further investment has ceased, there will be no intransitivities in the response.

In short, this model with infinite capacity for recall allows preference reversal and intransitivity, but only as transient phenomena. Once further investment in introspection ceases, preferences are stable and transitive. This result, although useful as an insight, is not as strong as it might appear, for it is not possible based solely on the responses to determine whether investment in introspection has ceased. In our normal distribution model we have the following result as well:

Theorem 4-6: For any number n there is a finite probability of obtaining unchanged results through n cycles with no intransitivities, and a preference reversal in the n+1st cycle. The proof of this theorem depends on the fact that normal distributions are unbounded. We conjecture that if the model is modified to deal with bounded distributions, this last theorem will no longer hold and more positive results can be obtained.

So far none of our conclusions are altered if we use the "comparison" formulation for introspection (recall that this is the formulation in which draws give not two values V_i and V_j, but merely the difference between them). The following result depends specifically on using the comparison formulation.

Theorem 4-7: Suppose that the initial question determines that U_1 is preferred to U_2 and the second question determines that U_3 is preferred to U_2. Then if investment yields only an estimate of the difference between the valuations of alternatives, it cannot be the case that a third question reverses the answer to the first question.

Proof: There is no incentive for further investment in response to the third question, since the second question only reduces the estimate of U_2.

If introspection gives estimates of both U_i and U_j, the conclusion of the theorem is weakened:

Theorem 4-8: Suppose the initial question determines that U_1 is preferred to U_2. Then preference reversal in question 3 is more likely if question 2 determines that U_2 is preferred to U_3

than if it determines the reverse.

In the case where two questions have already been asked, we are now in a position to compare the relative usefulness of various possible third questions. Here are the two relevant cases to consider:

Case I: Suppose the first question reveals Ul is preferred to U_2 and the second question reveals that U_2 is preferred to U_3. Then the most useful third question is to compare Ul with U_2 again, rather than to compare U_1 with U_3. In.both cases it is optimal for the investigator to base his predictions of true underlying preferences on the last two of the three responses; however, these optimal predictions are more accurate when question 1 is repeated than when the new comparison is made.

Case II: Suppose the first question reveals U_1 is preferred to U_2 and the second question reveals U_3 is preferred to U_2. Then the most useful third question is obviously to compare U_1 with U_3.

The resultant principles can be summarized quite neatly: Redundancy in questions can be useful. If redundant questions are used, it is more useful to doublecheck the earliest questions and the ones which full ranking indicates represent the closest calls. When redundant questions are used, rely on later rather than earlier answers.

4.4.9. Comparison Versus Scaling Questions

For the purpose of this section, we will assume that introspection yields an estimate of the value of only one alternative. We now wish to consider the difference between the effects of the following two questions: comparison questions ("Which alternative do you prefer?") and scaling questions ("How much do you value alternative X?") Both are commonly used in risk analysis and risk surveys and some of the difficulties with the results stem from the non-comparabilities of the two sorts of questions.

We need to establish some payoff associated with the answer to the latter question. In actual surveys this is typically accomplished by announcing to the individual that he will participate in what is equivalent to a second-price auction (Vickrey) with his announced valuation as his bid. Since truth-telling is a dominant strategy in such circumstances, in the case where introspection is costless, this gives the individual an incentive to answer correctly.

Giving the individual whichever alternative he says he prefers is also an incentive to answer accurately. The issue then is which format leads to greater introspection and therefore

greater accuracy in answering. In fact, comparison questions are special cases of scaling questions, since the second price auction framework in effect chooses the value of the alternative randomly and then presents the individual the realization, if the individual's bid indicated he would prefer it, and the initial alternative otherwise. A comparison question is thus a special auction in which the bid which will win is known with certainty beforehand.

Therefore the relative merits of the two forms of question can be determined by resolving the following: Which random distribution of alternative valuations induces the individual to invest most in determining his valuation of a specific alternative? The answer is the following:

Theorem 4-9: Investment in introspection in evaluating a propose offer is greatest when the value of the alternative to receive-if the offer is refuse has a distribution with mass concentrated at the expected prior utility of the proposed offer.

Proof: (Outline) By the results of the initial section, we know that among offers with identical variance, the one giving the closet mean utility to the proposed offer elicits the greatest investment. Thus concentrating all mass at the mean is of greater value than dissipating it across alternative possibilities.

If we know the individual's prior mean, then the best way to elicit accurate preferences is to have the individual choose between the alternative and the certain offer of the prior mean utility. In any application, of course, we will not know the decison maker's priors. Thus making a fixed alternative offer will yield variable amounts of investment across individuals depending on how close it matched each individual's prior mean. One approach then is to ask casually what the mean valuation of the individual is ("how much is this offer worth to you?") and then to give .the offer or the estimated value to the individual, whichever he prefers. The paradox of the difference between estimates made in some of the preference reversal literature is partially resolved then by the fact that greater investment is made when the actual offers are in prospect. This framework does, however, yield refutable propositions, since the initially stated preferences should be reversed about half of the time. If reversal occurs more than half the time, we must assume biases in the individual's initial estimates. Analysis of this situation must wait until the final section.

In any event, this analysis also gives a useful rule of thumb for scaling the distribution of offers in the alternative used in a scaling question: They should mirror the investigator's estimate. of prior means in a population sample.

4.4.10. More General Distributions of Priors

Thus far we have assumed a great degree of homogeneity: All alternatives and all estimations have been assumed to have independent distributions. In fact, much of the richness of a real decision problem comes from the non-independence of these distributions.

The structure we have developed allows for outcomes to be "similar" in several senses. First, two outcomes may have the same expected utility. Second, two outcomes may be considered similar if it is relatively easy to tell which one is preferred to the other. Finally, outcomes may be similar because there is a correlation between information about one of them and information about the other -- so that one becomes a useful predictor of the other. Each of these notions is important in describing the effects of learning about preferences and the relationship between learning about one alternative and learning about the next. In this section we begin to establish a framework which will enable us to explore this relationship.

To consider the effects of non-independence, we will assume that all alternatives have a factor representation, so that the utility associated with any alternative is

$$U_i = \text{Summation of } b_i X_i,$$

where the b's are weights and the X's are i.i.d. underlying factors. If we make this assumption, then we will describe one alternative U_i as a good predictor of another U_j if the two are closely correlated. In this framework correlation is simply

$$\text{Summation over i and j of } b_i b_j \left(\text{Summation over i of } b_i^2 \right.$$
$$\left. \text{summation over j of } b_j^2\right)^{1/2}.$$

In this framework, the answers to a question about an alternative are affected similarly by having asked previous questions about it or by having asked previous questions about a good predictor of it. In either case, the variance of estimate of the alternative is reduced, answers become more accurate, and the likelihood of further investment in introspection declines. In particular, any conclusion from preceding sections about the behavior of multiple questions applies approximately when all the alternatives in one of the questions in the sequence is replaced by a good predictor of those questions with mean utilities scaled up or down proportionately.

A second form of interdependence is attributable to interrelations in the error structure in the sampling. Suppose again that all the U_i's are independent, but that the e's in the various draws have a factor representation:

e_i = Summation $a_i x_i$.

The closer th'e correlation for any two alternatives i, j, the more can be learned from a given attempt to compare them. If we identify the x_i's with various measurement errors associated with the forms in which alternatives are presented, it is apparent that we desire a presentation which is as consistent as possible across alternatives. Moreover, if questions are designed to give the individual aid in learning about the forms of measurement error, then we can hope that associated errors may disappear in subsequent questions, as values of particular x_i's are learned.

So far we have assumed that the individual is passive in his choice of alternatives upon which to make introspections, only choosing the number of examinations to make of any given alternative. As long as homogeneity assumptions are maintained, there was little cost associated with this additional simplification; in answering a question about preferences between U_i and U_j it was always more useful to introspect on those two alternative than upon any other set. Once homogeneity is dropped however this need no longer be the case, as the following example demonstrates:

Example: Suppose there are three alternatives U_1, U_2, and U_3 and that U_1 is a good predictor of U_2 while U_3 is independent of either. Suppose furthermore that the error structures for U_2 and U_3 are highly correlated, while.the error structure for U_1 is uncorrelated with the other two. Then if the correlation between U_1 and U2 is sufficiently high, it is optimal for the individual to decide between U_1 and U_3 by introspecting on U_2 and U_3.

In other words, the structure is now sufficiently rich to rationalize the use of proxies and heuristics. If a decision is to be made where the measurement problems are sufficiently difficult, then the decison maker finds it advantageous in his work to substitute for the initial decision a set of alternatives which are good predictors but for which the measurement problems are less acute -- for instance, to simplify a complex lottery by substituting certainty equivalents for certain branches.

Note that although this structure can explain the use of heuristics, it cannot explain any biases observed in the heuristics used. For example suppose w.e structured a problem so as to make one set of heuristics most natural in one instance and a second set in a second instance. The model as it stands would not predict that every individual's answer be identical in the two instances, but it would predict that on average stated preferences would be the same in either realization.

4.4.11. The Effect of Limited Memory

It is important to realize that the framework as it has been described so far still has a significant limitation. An important simplifying assumption we have used is that of "perfect recall." No experiment, once made, is ever forgotten. Information becomes more and more precise as more and more questions are asked. This simplifying assumption leads to testable implications. As noted before, preference reversals and intransitivities occur in the model, but as transient phenomena. As more and more questions are asked, the number of reversals becomes rarer and rarer, and the effects of anchoring to the previous questions dies out.

If these predicitions are not upheld by the data, a natural way to keep preference reversals occurring is to allow for imperfect memory. We simply need to assume a limited memory capacity, so that records can only be kept for a fixed number of experiments. If the number of examinations made exceeds this fixed limit then each new examination replaces an earlier result. Beyond that point, we simply condition priors only by the last N observations (where N is the capacity of memory) rather than by the entire history.

Note in particular that this model is an extension of the basic random utility model. In our new framework we would interpret the random utility model as a special case in which memory can only contain one experiment at a time. A limitation of the simple random utility model is that responses cannot be autocorrelated, as they can when memory is allowed. On the other hand, in a finite memory model there is no tendency for preference reversals to die away or expenditure on introspection to cease. The following results are immediate:

Theorem 4-10: The smaller N, the more common are preference reversals, and the more likely are observed intransitivites.

Theorem 4-11: For a given question let R(n) be the fraction of the times that the answer is reversed between instances of posing the question, when the number of intervening questions is n. Assume that for some n, say n^*, there is no memory--i.e., none of the introspection that entered into answering any question is left n^* questions later. Then any period n less than n^*, $R(n)/R(n^*)$ measures the extent to which memory endures n periods.

Again, these results, although useful conceptually, are of less use in empirical implementations if the acutal capacity of memory is large. For if it is, the interview session would have to continue sufficiently long to gather a large amount of data relative to the memory capacity. Some investigators have attempted to overcome this limitation by posing some questions in several sessions with large amounts of time intervening. The theorems may serve as a basis of determining the success of this

technique.

4.4.12. Biases

In the previous sections we considered several cases where inconsistencies resulted; however the Bayesian structure left as an implication that the inconsistencies could not systematically be weighted in one direction or another. In this final section we develop models 'which will allow for systematic biases in individuals* estimates.

It is extremely difficult to develop a Bayesian account in which individuals are subject to bias. For example, consider a problem in which an individual is paid a reward for correctly estimating the length of a line. Suppose he has a measuring stick which is biased, and suppose he has had previous experiences with the biases of this measuring stick. Then his estimates will be made so as to undo any such biases. The only waythatthere will be **a biased** estimate is if the individual has not yet learned the biases of his instruments; once learned, rationality requires that they be compensated for.

In the case of estimating the utility of prospects, it is easy to believe that individuals have not yet learned all of the biases in their measurements. It is also easy to believe that unless they experience the gambles they are estimating their preferences over, they will not learn these biases during a questioning session, except inasmuch as these biases lead them into a logical contradiction.

On the other hand, we will wish to be extremely careful in incorporating biases into the model. The difficulty with assuming them is that they are too powerful. By assuming sufficiently complicated forms of bias it is possible to rationalize any sequence of preference announcements. Therefore in this section we **will** content ourselves with modeling the biases as occurring only in the priors and not anywhere else in the description. At one point we will demonstrate that for a certain class of examples this is informationally equivalent to assuming that the biases occur elsewhere.

The introduction of biases imposes a conceptual problem: In what sense can we obtain evidence of biases? We propose the following interpretation: Biases can be evident from a systematic set of information which influences tastes. For instance, if the data show a systematic tendency for alternative 2 to be valued more highly than alternative 1 at the beginnning of an interview than at the end, then this is evidence of some bias; individuals in initial periods might be expected to take advantage of this statistical regularity as a source of **exploitable** information about true preferences.

These biases can be incorporated by assuming bias In the individual's priors. Let us suppose that individual preferences

are drawn from a population with some given distribution. If individuals' priors are unbiased, then their priors as to their own tastes equal this population distribution. More generally, in cases where not all individuals are identical a priori, prior beliefs are defined as unbiased if for any particular prior, the sample distribution of, true beliefs of individuals holding that prior is identical with the prior.

We consider only the case of infinite memory. In this case "true" preferences are simply the asymptotic distribution after infinite numbers of samplings. Moreover, in this case, since the influence of priors dies out with time, biases disapppear. The existence of such biases can easily be tested, by comparing distributions of preferences implicit in initial questions on a survey with those implicit in final questions on a survey. The result of such an investigation will be of use in adjusting the results of short surveys to correct for prior biases.

A second way of formulating the account is to assume the biases are not in the priors but in the process of introspection. For instance, imagine that in introspections about one outcome U_1, the mean of measurment error e_1 is not zero, while in the corresponding outcome U_2 the mean is zero. However suppose that both e_1 and e_2 are treated by the decision maker as being zero-mean variables. Then the greater the amount of introspection that has occurred the more likely alternative 1 is to be preferred to alternative 2. Of course identical results would be obtained if priors were biased against alternative 1 and introspection were unbaised. Thus we will continue to use the 'formulation in which we ascribe all bias to the priors.

Similar, but more subtle forms of bias can be demonstrated through over-dependence on initial introspections, over-valuation of current information, and so forth. In all cases, the test of bias boils down to a claim that statistically, the answer to a question conditioned on any information set or a set of previous questions should equal the answer to the question conditioned on any additional information. If not, then, the earlier estimates were not making use of the available information. To have anchoring in this sense will require bias.

For our purposes, the most interesting example of bias is the case where the conditioning event is the form in which an alternative is presented. If there is no bias in the preference priors then statistically about as many people should prefer an alternative independent of the form of its presentation. In what follows we will generate an account within which biased priors can account for the inconsistencies and therefore can generate preference reversals of the form described in Grether and Plott.

4.4.13. Example of Biased Priors Generating Preference Reversals

Suppose U_1 is a complicated alternative which has a factor

structure

$$X_1 + x2 + x3 .$$

Suppose U2 has the structure X_1+X_2; and, suppose U_3 has the structure X_1+X_3; also, suppose we wish to compare U_1 with U_4 which has the structure X_4. All X's are i.i.d. normal.

Suppose that the measurement error structure for the U's is

$$V_1 = U_1 + e_1$$

$$V_2 = U_2$$

$$V_3 = U3$$

$$V_4 = U_4 + e_4 .$$

Suppose that el is large compared to X_2 or X_3 so that it makes sense to compare U_4 with one of the predictors U_2 or U_3 rather than directly with U_1.

Suppose that U_2 and U_3 are ex ante identical so that it does not matter which the comparison is made with and finally suppose that the costs k are sufficiently great that a single draw is optimal.

Under these circumstances, without bias we would predict that statistical results would pick U_1 or U_4 with frequencies independent of whether V_2 or V3 were used as the predictor. On the other hand suppose the true distribution for U2 is

$$X_1+X_2+h$$

where h is positive. Then although the indivdiual treats the predicting alternatives as equivalent to alternative U_1. alternative 2 is likelytobe preferred to 1. The result is that U_1 is announced as preferred to U_4 more often if the comparison is carried out by means of U_2 than if it is carried out by means of U_3.

If the biases in individuals' estimations enter through the priors as we have described them here, then we have a testable implication. Questions asking the individual to compare U_1 with U_2 or U_3 will cause the individual to invest in introspection along those dimensions, reducing the influence of the priors and making it more likely that h is included in the measurement Thus we have:

Theorem 4-12: If biases occur in the priors then they will be reduced by questions which focus on the comparisons in which the

biases occur.

In this example, if two presentations of the data apparently lead to different preferences, then the biases might be reduced by asking directly for comparisons either of the two presentations, or of each with the predictor which we expect has been derived from it.

4.4.14. Summary and Implications for Contingent Valuation

The model of uncertain preferences in section 4.4 provides a framework to guide the application of contingent market methods to estimate the value of health risk reduction. Following a critique of expected utility theory and a discussion of the theory of individual values and behavior towards risk, a series of theorems have been developed that resolve difficulties with survey responses in terms of the behavior of a rational respondent making a costly examination of his own preferences when faced with questions that call them into play perhaps for the first time.

The key to the problem of obtaining consistent, valid measures of risk values, according to the theory that has been developed in section 4.4, is dealing with the fact that people are often highly uncertain about what their risk preferences and values actually are. This is to be expected because people infrequently have occasion to think carefully about risky events. They seldom have occasion to examine their own reactions to the influences to opinion-molding surface events. Careful, systematic reflection is required, just as is required before deciding on an operation, a risky investment, or other difficult decisions that arise from time to time in everyone's life. While bias may enter into the valuation process, the economic approach of section 4.4 postulates that people learn to correct for the influence of their own biases when they become aware of them. A model has been developed and a series of theorems derived that have implications applicable to the task of eliciting consistent, valid risk reduction values.

The propositions of this section coming from a model of rational behavior replace assertions from the psychology literature that apparent preference reversals and sensitivity to framing show that people are irrational. In the present section, these phenomena are viewed as being due to the costliness of information.

Theorem 4-l concerns reducing an individual's uncertainty about his own preferences. The question posed is how an individual can make the best choice when faced with a pair of alternatives. The theorem says that less new information is required the greater the difference in the value received from each available choice. It also says that the more certain the individual is about the values of the alternatives, the less new

information is required to make the right choice. Finally, less new information will be acquired the greater the cost of acquisition.

The reminder of theorem 4-l contain several propositions about the accuracy of preferences that are stated after an individual has acquired additional information. The theorem holds that announced preferences are more accurate the greater the difference in value received from each available choice. Preferences are stated more accurately the more certain individuals are about the value of the alternatives they face. Finally, announced preferences are more accurate the lower the cost of acquiring new information.

An application of theorem 4-l is found in the use of the floating starting point in sequence of iterative bids. Consider the 7-symptom Health Questionnaire: One day, reproduced in Appendix A.1 of section 3. The sequence proceeds from an arbitrary startingbid of $100 to get rid of the least bothersome symptom. The starting point for the next bid, concerning the most bothersome symptom, is set at twice the first bid, based on the guess that such a value might be a fairly close approximation to the respondent's value. The theorem says that the respondent will think more carefully about his preferences at the outset the closer the guess is to his value for the contingent market product.

Theorem 4-2 concerns outcomes of risky situations in which the values associated with alternatives may not actually be received, but are received only with a probability less than one. The theorem states that people expend less effort in getting to know their own preferences the smaller the probability of actually receiving the stated values of alternative choices available to them. It also states that actual expressions of their preferences are less accurate the more uncertain it is that they will receive the payoff.

The fact that no actual transactions occur in the contingent market surveys is a disincentive to careful thought on the part of respondents. This has been recognized by researchers for a long time. The disincentive is partially overcame in public policy applications by appealing to respondents' willingness to cooperate in accomplishing an important endeavor.

Theorem 4-3 pertains to the way people allocate their efforts to know what their risk preferences are. If people reflect on a series of alternatives, they will devote less and less effort and attention to later alternatives to the extent that they are related to alternatives previously considered. A similar result occurs when there is dependence in the sampling and people discover the values they place on differences.

One of the most difficult decisions in the construction of the health surveys is to decide on the number of contingent valuation questions to ask. Expertsnce reveals that there is a

tradeoff between the quality of responses and the volume of information sought. Theorem 4-3 explains this experience. When long' question sets are asked about similar contingent products, people tend not to think independently about each of them. It tends to be their reliance on previous introspections rather than often-postutated fatigue that produces this result, according to the theorem.

The theorem implies that a series of related questions can lead people to think about the differences between contingent goods rather than considering them as independent alternatives. This behavior can be exploited by encouraging people to think about differences as they express their values for programs. For example in the '/-symptom health questionnaire of section 3, people were asked to carefully consider each symptom in turn and rank them from least to most bothersome. Bids were then obtained for the two extreme symptoms; iteration was used to encourage as much thought as possible. Bids for the five intermediate symptoms were then written down directly on the assumption that the comparison exercise had made their values apparent.

Theorem 4-4 addresses the problems of preference reversal and intransitivity that are frequently observed in expressed valuations of risky outcomes. If preferences are uncertain and information is costly to obtain, inconsistencies or outright reversals may occur as individuals reflect upon their preferences. True preferences are more likely to be stated during later stages of reflection. A related theorem states that if reflection on the same list of risky alternatives continues, a point is reached where further reflection will not be attempted and expressed inconsistencies are eliminated. This result depends on several assumptions, among which is that the individual does not forget any of the earlier steps in the reasoning process. If the reflection process produces only estimates of the 'differences in outcomes, then further probing of preferences can not produce preferences reversals, simply because there is no incentive for such further probing of these outcomes.

An effort was made in constructing the health questionnaires to utilize apparent preference reversals as part of the process of respondent introspection about preferences. For example, in thinking about how much they would be willing to pay to relieve symptoms respondents sometimes change their minds about thefr beliefs when they were working out their rankings. Accordingly they were encouraged to change their responses, several times if necessary, until they arrived at a set of rankings and values that satisfied them.

The following theorems suggest additional approaches to stimulating introspection about preferences where preference reversals and intransitivities are present in survey responses These hold considerable promise for further work.

The practical content of theorems 4-5 through 4-8 is that repeated questions concerning preferences are often useful. If

repeated questions are used in the reflection process, it is most useful to doublecheck 'the earliest questions and the ones in which the earlier rankings suggest the closest calls.

Reflection about preferences frequently takes one of two forms: comparison- -which alternative do I prefer?; and scaling-- how much do I value alternative X? The question that induces the greater amount of investment in additional information is the superior question to use in any given circumstances, Theorem 4-9 states a condition on the most effective way to stimulate effort to get new information. Suppose one constructs an offer of alternatives: one whose value is sought and another whose value is fixed at some given stated value. The best given stated value is that closest to the prior value of the alternative of interest, i.e. the value before new information has been acquired.

Theorem 4-9 has a very important lesson for the construction of contingent market goods. It received careful application in the 7- symptom questionnaires of section 3. This was accomplished by framing willingness to pay questions in terms of the respondents' endowments, with which they were familiar and presumably had clear ideas about in utility terms. Additional amounts of symptoms were then added to those they already experienced. Thus respondents were presented with two alternatives: Alternative X- -their current situation; and alternative Y- -the situation with added symptoms. They were then in affect asked a scaling question- -how much do you prefer situation X. Theorem 9 says that by relating the policy alternative (Y-X) to the respondent's own endowment rather than some less familiar reference point **X'**, the respondent invests more effort in thinking about his own real preferences.

Further work needs to be done along these lines on the life path scenarios on heavy symptoms reported in section 4.5. For example, certainty scenarios begin with a person of age 50 and present life path alternatives with later ages. Application of theorem 4-9 suggests that people who are younger or older than 50 do not have strong prior beliefs about their health values at age 50, and will not invest much effort in making accurate WTP statements about the alternatives. Investment in introspection would be increased if these scenarios were tailored to each respondent's actual situation.

The foregoing theorems assume that there are no memory limitations that reduce the effects of information gathering about preferences. Relaxing this assumption yields a theorem that says that the more limited is memory capacity the more numerous will be instances of preference reversals and intransitivities.

Theorems 4-10 and 4-11, of limited empirical usefulness when memory capacity is large, provide a method of measuring the extent to which memory endures during a period of reflecting about preferences.

A problem of importance in discovering the values of uncertain preferences is the presence of bias. The problem is for the individual to learn the size and direction of his biases and correct them in discovering his underlying preferences. Questions arise during reflection in which biases occur. Theorem 4-12 states that biases will be reduced by questions that focus on comparisons of alternatives in which the biases occur.

In conclusion, the framework we have built, although rudimentary, allows us to address several of the most vexing problems which arise in researchers' attempts to make use of data from risk surveys. It has been constructed as a series of nested generalizations starting from expected utility theory and gradually dropping or modifying assumptions that have been refuted in one or another examination of responses to survey questions.

Although the outlines of the model at every level are clear, there remains much to be done. In particular when the homogeneity assumptions are dropped there remain a great variety of unexplored possibilities. It will be most useful to tailor specifications of assumed structural relationships between the priors on various alternatives or the measurement errors of various acts of introspection to the specific description of the alternatives in any particular experiment. Once this is done we can begin to make useful inferences from watching individuals' behavior in the face of specific complicated offers, and learn which sorts of simplifications individuals actually make in estimating preferences.

Similarly, there is much work to be done in specifying particular biases to which we would wish to attach the priors. Here previous psychology studies will be most useful for providing insight as to the most reasonable specifications. Tendencies to overestimate small probabilities and to underestimate large quantities can be among those considerations we capture in the biased priors. In short, although the structure is now available, much work remains to be done in terms of specific applications.

4.4.15. References

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4.5. DESIGN OF CONTINGENT VALUATION APPROACHES TO SERIOUS ILLNESS

4.5.1. Special Problems of Contingent Valuation Encountered With Serious Illness

The valuation of serious illness entails a number of analytic problems that are fundamentally different from the valuation of minor illness and light symptoms experienced occasionally by everyone in relatively unpatterned ways throughout their lives. Thus the analysis of section 4 requires

completely different analytic techniques from those employed in section 3, even though it builds on the survey research knowledge obtained there.

Two fundamental aspects of behavior, relatively unimportant to the study of light symptoms, are introduced in section 4. The first of these is risk. Serious illness, dreaded by people at some stage of their lives, is a prospect they face with varying degrees of probability. Because people have some control over the probability of serious illness, their behavior in the face of serious health risks is an important measure of the value they attach to good health prospects. Hence it is important to understand people's attitudes towards health risks.

The second fundamental aspects of health behavior is the way prospects vary over a person's lifetime. In younger persons, choice and consequence are often separated by many years. Over time one's health prospects change, and behavior tends to be modified accordingly. At the same time, life expectancy becomes a matter of conscious concern. How one responds to these interrelated matters depends in large measure on the social and economic circumstances of one's life, and on how one has cared for his health in the past. Thus the focus of section 4 research turns to an integrated view of serious illness and death in the context of a person's overall lifecycle experience.

Accordingly+ section 4.2 explicitly introduces the concept of health as a behavior-dependent condition of overall well being. Operationally, a narrower version is adopted--health is measured in terms of its absence, or in terms of the amount and types of the person's ill health. This narrower operational definition preserves the prespective of the broader, more satisfactory definition by being embedded in a life cycle model of quantity and quality of life, developed in section 4.3,

Section 4.4 addresses the difficult problem of eliciting expressions of people's behavior towards risks to health. Respondents will have thought about these matters to a greater or lesser extent and adjusted their behavior accordingly. The research challenge is to obtain quantitative equivalents to the sometimes nebulous attitudes that govern health behavior in the face of risks. The current state of utility theory leaves unanswered the question how best to obtain these quantitative equivalents in a form suitable for use in welfare analysis. Section 4.4 provides the inquiry required to guide the investigation along sound theoretical lines.

The empirical framework that resulted from this conceptual investigation is presented in section 4.5. This empirical framework takes the form of a four-module approach to the valuation of health-risk reduction. The first module, health experience, quantifies the respondent's health endowment according to the operational definition of health established in the conceptual work of section 4.2. Health costs and defensive measures, the second module, quantifies certain important money

outlays and nonmarket behavioral costs incurred on behalf of health. The module on risk perception and risk behavior prepares respondents to think carefully about the kinds of probabilites involved in behavioral decisions about serious illness and longevity. This involves a prepartory session to impart an intuitive grasp of the elementary principles of probability. It also obtains information about respondents' behavioral responses to a variety of risky situations. The fourth module presents the contingent valuation questions used to obtain values related to longevity and reduction of risk of serious illness. The goal of these questions was *to* integrate prospects for serious illness and death into an integrated life cycle approach. The questions progress from simple life experience situations to more complicated life path situations involving various probabilities of serious illness and death.

The four-module approach requires about three hours to complete, including breaks for relaxation. Designing a survey of this complexity and duration is a novel research enterprise. Past economic survey experience suggests it to be too taxing of respondents' patience and stamina. In view of this experience the necessity of taking steps to avoid fatigue was apparent. Taking several breaks at intervals defined by the modules is the simpliest of these. Use of this Health Risk Appraisal also serves this purpose by providing an interactive computer program approach to obtaining information about the respondents' health endowments. Respondents are aware that the program output gives them information about their own health status, which is expected to sustain their interest and energy while at the same time providing information that will unable the contingent valuation questions to be tailored to their own life situations. Considerable thought has also been given to devising entertaining probability teaching devices that can accomplish their task with a minimum of effort. The contingent valuation questions themselves are designed to capture the interest of respondents. Path-of-life situations are presented with the assistance of such devices as a type of roulette wheel that respondents manipulate, and with various card-game analagies with which many are familiar. Lastly, the incorporation of in-depth marketing-research interview techniques will be employed in order to make the exercise as effective as possible.

Much work on morbidity has pertained to non life-threatening diseases, including section 3 of this report. At the other extreme, there have been many studies of mortality, as reflected in an extensive value of life literature. Serious illness has been relatively neglected. Only the health expenditure approach has given much attention to serious illness. As was brought out in section 2 of this report, which concerned comparative analysis of approaches to valuing health, the health expenditure approach suffers from crucial conceptual problems, and at best it gives lower bound estimates.

Serious illness involves valuation problems that combine pure morbidity effects and value of life and mortality effects

It might be thought that serious illness could involve only morbidity and not mortality., However there are two important reasons why the valuation of serious illness must be concerned with both morbidity and mortality. First, most serious illness is life threatening. Increased risk of death becomes a cost of the illness along with more usually recognized morbidity effects such as medical expenditures, lost work and discomfort. Second, serious illness affects the quality of life in an extreme way. The value of life is affected by the quality of life as well as its quantity. That is, the value of life depends on well being during life as well as the number of years lived. The traditional value of life literature may be interpreted as pertaining to duration, or number of years of life, assuming cause of death does not affect the quality of life.

In this regard the usual value of life approach to death from a disease like cancer, coming at the end of a lingering illness, understates the costs of cancer. Cancer reduces the number of years of life -- which is taken account of by the traditional value of life approach, and it also reduces the quality of life while living -- which is ignored in the traditional value of life approach.

Recognizing that serious illness involves both the quality and quantity of life leads to a reformulation where morbidity and mortality are considered in a common framework. One of the most important results of using this framework is to view values of serious illness in terms of tradeoffs between the quantity and quality of life. In this section we develop and apply this framework.

In addition to raising questions about the relationships between the quantity and quality of life, serious illness is more complicated than non-serious illness because risk is an important consideration. Perception of risk is a prerequisite to intelligent valuation of serious illness. Just as with death, the value attached to serious illness with certainty is different from the value attached to small changes in the probability of the illness, which in the aggregate mount up to the same number of deaths.

People's knowledge of risks and their abilities to verbalize their attitudes toward risks are notoriously difficult areas, which must be dealt with if the contingent valuation approach is to have hope of yielding reliable results. In addition to perception and knowledge about risks, issues arise concerning behavior in the face of risk. The degree of a person's risk aversion will influence how greatly he values a reduction of the probability of the problem of a serious illness.

The present section draws on the three previous sections in devising a contingent valuation approach to serious illness. Section 4.5.2 first states why in-depth interview techniques are needed in the valuation of serious illness. Then the basic structure of a four module interview approach is described. The

four modules pertain to 1) health experience, 2) health costs including defensive measures, 3) risk and 4) contingent value questions. Sections 4.5.3 through 4.5.6 describe the four modules in detail. Finally section 4.5.7 draws implications from preliminary experimentation with the modules and makes recommendations 'for further work.

4.5.2. Rationale and Overview of Four Module Approach

Early focus group efforts indicated that respondents have great difficulty in a short interview in forming quantitative opinions on small risks and heavy health damages outside their everyday experience. An in-depth four module approach was therefore developed. The four module approach establishes the basis for intensive interviewing for the study of life threatening illness..

4.5.2.1. Health Experience

The first module, health experience, establishes the respondents' health endowment and health habits as part of the explanation of willingness to pay survey responses. It also helps respondents focus their attention on the subject of the survey and prepares them to give carefully thought-out answers.

4.5.2.2. Health Costs And Defensive Measures

The second module deals with the costs of maintaining health and treating illness. It considers defensive measures taken to promote health and avoid illness as well as expenditures to treat illness. Respondents are asked to recall the number of days of work and recreation that were lost because of illness, and also the number of such days that were partially impaired by illness. Defensive measures include all behavior intended to avert risks to health and life. They comprise actions identifiable by market expenditures and also behavior that is costly to the individual in a non-market sense. Non-market preventive measures include both abstinence and health producing activities that in part, at least, do not yield utility directly.

Measurement of these activities is part of the empirical framework for studying behavior towards risk. They are an important part of the behavior by which people reveal the values they place on improved life and health prospects.

4.5.2.3. Risk Perception And Risk Behavior

The third module, risk perception and risk behavior, gives the respondent an intuitive grasp of probability and discusses

the importance of the concept in everyday life. Fundamentals of probability are discussed using everyday language supplemented by physical devices such as urns from which drawings illustrating randomness and chance are made. Following this grounding in probability, the respondent's attitudes towards risk and perceptions of the danger of various activities are explored. Respondents are asked how they attempt to keep risks downintheir life at present. They are asked what they would do if exposed to greater or less risks than at present.

4.5.2.4. Contingent Valuation Questions

The fourth module pertains to the construction of the contingent market. The contingent valuation (CV) exercise provides the basic valuation data that permits estimation of the benefits of health risk reduction. The CV module has been designed in segments.

The first segment concerns mortality, for which alternative approaches to presentation have been developed. The first is the excess deaths approach, which pertains to the increases in death rates in various age groups because of some particular cause of death such as cancer. The second is the life expectancy approach, which states the average age of death in the U. S. population, and establishes contingent market programs that would increase life expectancy. Bar charts that illustrate the probability of living beyond age 50 with and without the program are introduced. The third method is life shortening. This is similar to life expectancy, except that it can be presented without mention of probabilities. A bar chart illustrates the average remaining number of years at five-year age intervals beginning at age 50. Program effects can be shown by changing the height of the bars. The last two methods devised to present mortality are a lottery wheel and a card game. The lottery wheel has a spinning arm with a pointer that comes to rest in a zone of the board that corresponds to a given life experience. It is useful in conveying the probabilities of occurrence of many life-health situations. The card game involves the chance occurence of drawing a card indicating that a sickness such as a heart attack will occur. The respondent is asked about willingness to pay to reduce the number of sickness cards in the deck.

In the second segment of the CV module, questions about several kinds of illness of varying degrees of seriousness are asked. Two types of contingent markets are utilized. In the first, a disease specific approach is used in which disease is mentioned by name. In the second, a health attribute approach is used in which only the symptoms are mentioned.

In the next section of the CV module several specific and explicitly depicted comparative life paths are presented, with symptoms and illnesses of varying severities and different life expectancies. Respondents are asked first to rank alternative life paths according to their preferences. A hypothetical life

path endowment is postulated, and willingness to pay and accept questions are asked, based on respondent rankings. The questions are constructed so as to reveal the strengths of preferences in choices involving severity of symptoms and length of life. These tradeoffs are offered in terms of certainty prospects.

The following section explores how health valuations are affected by the existence of risk. The respondent is offered one life path with certainty and pairs of alternative life paths -- one better and one worse -- with various probabilities. Respondents are asked about their willingness to pay for the scenarios.

Willingness to pay questions are asked based on the life path preferences. A base life path endowment is established and programs that would improve or prevent deterioration of the environment are offered. The program effects are linked to the life paths. Linkages are not established between dollar bids and probability statements. It would be possible, however, to apply this contingent valuation structure to obtain statements of willingness to pay for risk reduction in future work.

Based on the four module formulation and focus group experience, refinement and development of alternative approaches for each of the modules was undertaken. The approaches are illustrated in the next four subsections. They provide the basis for possible future field work.

4.5.3. First Module: Health Experience

The first module, health experience, develops the information and preference context of the questionnaire. It serves two research purposes. The first is to focus the respondents' attention and research their references on the subject of the survey and prepare them to give carefully thought-out answers. The second purpose is to establish the respondents' health endowment and health habits as part of the explanation of willingness to pay responses to survey questions. The questions encourage the respondents to link health status to the behavior and activities of daily living. Their perceptions about psychological well being and degree of control over personal health reinforce the connection between health and behavior, which will be important later in reflecting on the value of health preservation or improvement.

Obtaining detailed knowledge of respondents' experiences with specific kinds of life threatening illness is an important part of the health appraisal framework. Detailed information about specific health problems of interest in the survey supplement the more general health status information obtained earlier. The empirical framework integrates mortality into the study of behavior towards risks to health and life. Some recent theoretical contributions have recognized that death has important endogenous elements in life cycle choices, but the

present study goes farther than others in empirically integrating mortality into the investigation of the value of risk reduction in a life cycle context. It accomplishes this by making the prospective life path of the respondent the basis for the contingent market good. The following abridged set of health status questions 'was developed to meet these ends.

Self-assessment of health status:

1. In your own opinion, which one of the following best describes your current health status:
1 Excellent 2 Good 3 Fair 4 Poor

Belief concerning control over health:

2. Which one of the following best describes the control you have over your health?

1 There is little I can do because it is beyond my control.
2 I can do **some** things, but they have little effect.
3 My actions have a moderate effect.
4 My actions have a great effect.

Detailed questions on health status:

3. Are you unable to do certain kinds or amounts of work, housework, or schoolwork because of health?
Yes _____ No ---------
If **"yes"** then 4.

4. Have you been unable to do this work for more than three months? Yes _____ **No** ---------

5. Does health limit the kind of vigorous activities you can do, such as running, lifting heavy objects, or participating in strenous sports?
Yes --------- No ---------
If "yes" then 6.

6. Has health limited the kinds of vigorous activities you can do for **more than three** months?
Yes ------a-- No ---------

Questions about sick days:

7. What conditions (such as specific illness and injuries) caused you to'stayinbed?

8. How many of the days that you lost from market work did you stay in bed all or most of the day?
-e---e--- days

9. During the last year, how many days did you cut down for as much as a day?
_____ days

What condition caused you to cut down?

General questionsabouthealth perceptions:

10

	Definitely true	Mostly true	Don't know	Mostly false	Definitely false
According to the health professionals, my health is now excellent	5	4	3	2	1
I try to avoid letting illness interfere with my life	5	4	3		

Focus group experience indicated that respondents are willing to answer these questions. They served their intended purpose well, but consumed too much time in a conventional interview context. For use in a half-day, in-depth interview, however., their use is feasible and deserves further consideration.

4.5.4. Second Module: Health Costs and Defensive Measures

Much of the material in this module is very similar to the modules on health costs and defensive measures already presented in section 3. The earlier material will not be repeated here. In addition to the earlier material, defensive measures toward serious illnesses that have low probability risk are explored.

An illustration will be presented here of questions about willingness to undertake changes in lifestyle to reduce risk of serious illness. The illustration centers on diet.

Referring again to cancer probabilities, imagine you were told by your physicianthatthe cancer life path is what you had to look forward to --because of some condition he had just discovered. He offers you a program, however, which will give you a 50% chance of avoiding the cancer scenario and getting the health scenario instead. His terms are this:. stop smoking, stop drinking, and immediately adopt a Special diet (not shown Here). Would accept the doctor's program?

Yes _____ No _____.

If yes: Are you confident that you would be able to adhere to these terms for the restofyour life?

Very confident ----------
Somewhat confident ----------
Doubtful ----------
Virtually no chance _____

If no: Suppose the doctor told you that you could be certain of improving your prospects to thehealth scenario. Would you accept the doctor's program?

Yes --------e **No** ---------

If no: What is the most difficult part of the doctor's program for you?

Rank them 1, 2, 3.

Diet _____
Drinking ---------
Smoking ---------

If Diet: Would you accept the doctor's program if it only required the Special Diet?

Yes --------- No ---------

If no: Would you accept the doctor's program if there were no dietary restrictions at all?

If yes: Repeat above.

If no: [Eliminate second most difficult part of

doctor's program and repeat.]

Building on this illustration, iteration on defensive measures could be used as part of the contingent valuation modules considered below in section 4.5.1.3. Hypothetical future life experiences would be ranked from worst to most desirable. The respondent wold then be endowed with the worst path and asked to bid for more desirable alternatives. Bidding would be in terms of defensive measures involving smoking, drinking, diet and exercise. Iteration would be used to determine how much averting behavior would be tolerated in order to improve life prospects by various amounts. Some experimentation with uncertainty could be introduced by setting the probability of payoff equal to 50 percent. The respondent would be asked how confident he is of being able to stay on the various programs, and which parts of the programs are the most difficult. The latter responses would be used in further iterations by eliminating the most difficult parts of a rejected program and asking if it would then be an acceptable price to pay for a preferred life path.

The rest of this iterate-on-defensive-measures approach entails eliciting willingness to pay (WTP) in dollars for the programs, based on their careful thought about sacrifices made for measures they are already taking.

4.5.5. Third Module: Risk Perception and Risk Behavior

A major result of work with focus groups is recognition of the need to carefully educate respondents in the basic concepts of probability and risks. The procedures, whose principles are discussed in detail in section 4.4, are necessary if respondents are to be able to respond intelligently about low probability environmental threats to life and health.

It is furthermore important to delve into people's general risk perceptions because they underlie judgements and choices in particular risky situations. The risk percetions help to explain choices in contingent markets for health risk. Asking respondents to reflect on these attitudes brings them more clearly to mind, improving the quality of contingent valuation responses.

Examination of people's actions in various risky situations reveals attitudes towards risks, just as do their prior perceptions of risk. These risk attitudes, formed over long periods under innumerable influences, are important determinants of behavior towards health risks, and are therefore likely to be important to analysis. Responding to risk behavior questions also helps prepare the respondent give well considered contingent valuation answers.

It is thus apparent from the focus group experience that a major experimental effort is required to develop teaching devices that will permit the effective use of probabilistic contingent

markets in health. Basic drills for teaching probability are not presented here. The defensive measures module contains some information on risk behavior which could be extended. Building on the present module, games have been devised using a lottery wheel and cards directly in contingent valuation questions as will be reported on in Section4.5.6.

The presentation in the present section is limited to questions on risk perception, which are as follows.

Risk perception, relative to past:

1. Relative to your parents' experience, the risks to health and safety you are faced with are:

   1 Much less
   2 Somewhat less
   3 About the same
   4 Somewhat greater
   5 Much greater

General awareness and concern:

2. Risks to health and safety come from a variety of activities, substances and technologies. Which causes the greatest, second greatest and third greatest concern to you? (Put appropriate number in each box.)

   1 Crime
   2 Swimming pools
   3 Nuclear power
   4 Alcoholic beverages
   5 Pesticides and herbicides
   6 Home gas furnaces
   7 Air pollution
   8 Power lawn mowers
   9 Smoking
   10 Motor vehicles
   11 Food preservatives
   12 Asbestos
   13 Water pollution
   14 Job risks
   15 Other (specify) _____

   [ ] Greatest concern
   [ ] Second greatest concern
   [ ] Third greatest concern

Ranking questions about causes of concern about risks and also about household production of health and safety:

3. Much has been said about various risks to health and safety. Using a scale of 1 to 10 going from least risky to most risky, enter the number you feel best describes the risk.

Crime	Swimming Pools	Nuclear Power	Alcoholic Beverages	Pesticides and Herbicides	Home Gas Furnace	Air Pollution
[1	[I	[1	[1	[1	[1	[1

Power Lawn Mowers	Smoking	Motor Vehicles	Food Preservatives	Asbestos	Water Pollution	Job Risks
[ ]	[1	[1	[1	[1	[1	[I

4. To what extent are the risks knownbypeople exposed to the risk? Use the following scale.

   risk level known precisely 1 2 3 4 5 risk level not known at all

   Knowledge [ ] (Enter the number 1,2,3,4 or 5)

5. To what extent through your own actions can you control exposure to the risk? Use the following scale.

   exposure. can't be controlled at all by individuals 1 2 3 4 5 exposure can be completely controlled by individual

   Exposure control [ ] (Enter the number 1,2,3,4 or 5)

6. To what extent can you by personal efforts and use of available resources control the outcome if you are exposed to risk? Use the following scale.

   outcome can't be controlled at all by individuals 1 2 3 4 5 outcome can be completely controlled by individual

   Consequence Control [ ] (Enter the number 1,2,3,4 or 5)

This set of questions, while effective when used in a focus group session, would be too long for a door to door survey. Use of these questions in a half-day, in-depth interview settfng would be effective, however.

4.5.6. Fourth Module. 'Contingent Valuation Questions

4.5.6.1. Mortality

Several methods of presenting mortality risks were developed and tested in focus groups. Five methods are-reported on here: excess deaths, life expectancy, life shortening, use of a lottery wheel, and use of a card game.

Excess Deaths

The following sample illustrates the excess deaths approach -- possibly the most easily understood idea of mortality risk:

> We have all used the term "epidemic" to describe the outbreak of a disease. An epidemic is said to exist when more people develop an illness -- measles, flu, for example -- than is expected under normal conditions. Similarly, the term "excess deaths" can be used when more people die from a certain illness or condition than is normally the case.
>
> For example, suppose that on average, 1000 people die every year in fires in the United States. If 5000 people were to die this year in fires, those additional 4000 deaths could be thought of as "excess," that is, more than could normally be expected to occur. Some scientists warn that pollution of the air and water cause excess deaths in the population today.
>
> Q. How much would you be willing to pay to eliminate one excess death due to air pollution?

Life Expectancy

Various approaches were tested to present the idea of life expectancy, changes in life expectancy, and people's willingness to pay to get improvement or avoid decline. One type of life expectancy question offered a rather elaborate contingent market to the respondent. The following example contains explanatory narrative that relates life expectancy to cancer, and illustrates a life path for a person of age 50 by means of the bar charts.

> Of all the possible consequences to human health arising from pollution problems, the threat of cancer may be the greatest source of concern. It is the only major cause of death which has continued to rise since 1900. It is difficult to determine how great a role

pollution plays in causing cancer. People differ in age, place of residence, occupation, health status, diet and lifestyle, and all of these factors together influence the probability of developing cancer.

Please look the first set of bars (see figure 4-7). These bars illustrate the overall probability of a person surviving from the age of 50 to the ages shown. For example, the likelihood of living to age 80 is about 48%, to age 85 about 308, and so on. (Of course, it is impossible to predict how and when a person will die; many factors will influence that event. The probabilities shown here are national averages)

Now look at the second set of bars. They show the probabilities of surviving to advanced age, but also the changes in the percentages if cancer were eliminated as a cause of death. Without cancer, the chances of living to be 80 or 85 would increase to 55% and 37%, respectively.

Suppose that it were possible to devise programs that would eliminate all cancer.

Q. How much would you be willing to pay for the programs?

Maureen Cropper comments that asking a person to value changes in life expectancy is somewhat ambiguous and does not necessarily measure what one wants to measure. Suppose Dj represents conditional probability of death at age j and $q_{j,t}$ represents the probability of surviving to the beginning of the j^{it} year given that one is alive at age t. It follows that

(4-43) $q_{j,t} = (1-D_{t+1}) \ldots (1-D_{j-1}), \quad j > \text{or} = t.$

Furthermore, life expectancy at age t can be shown to be

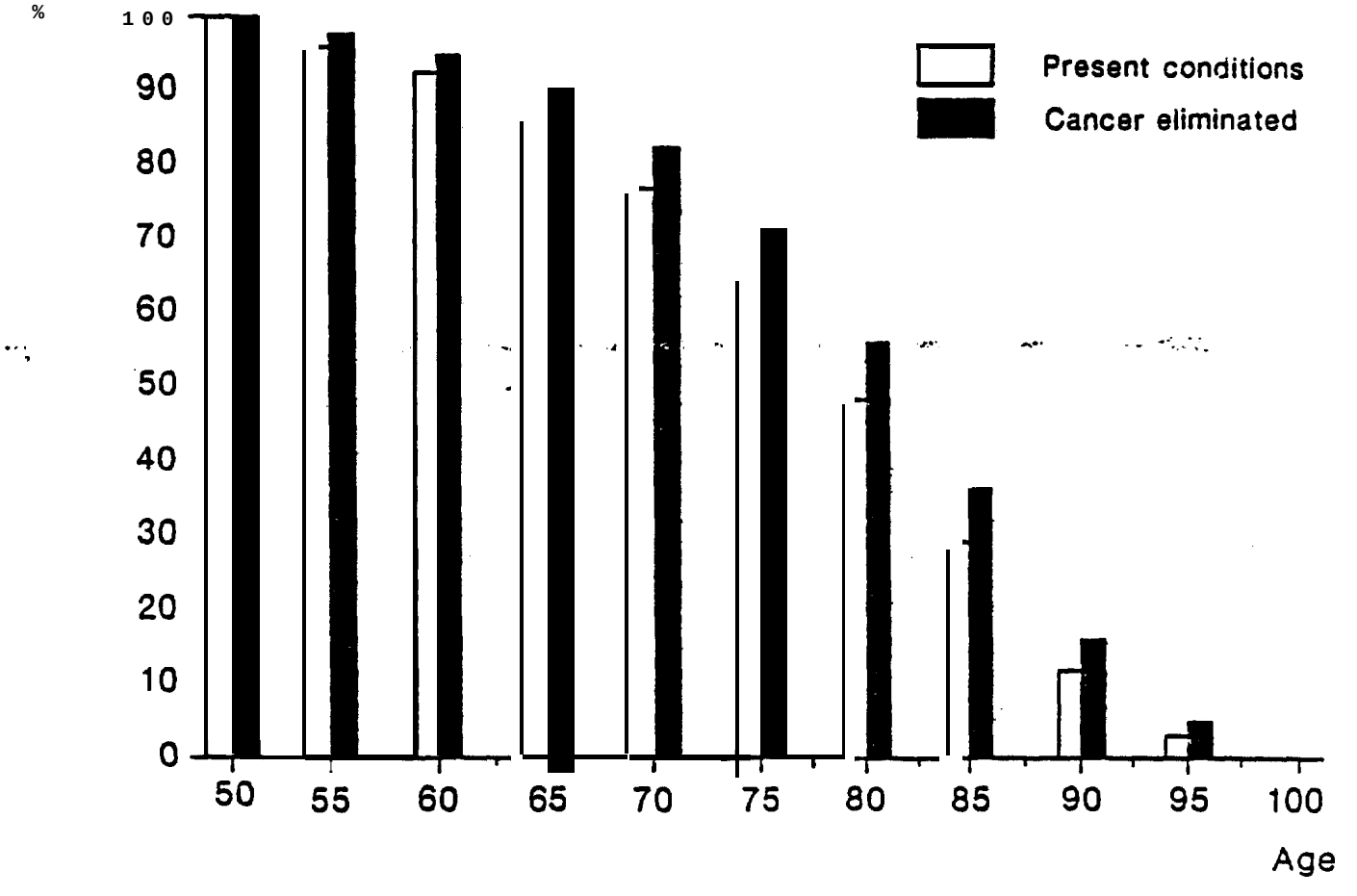
(4-44) Summation of q_{jt} from j = t+1 to T.

Equation (4-44) indicates that a change in life expectancy is ambiguous in the sense that there are many sets of changes in the $q_{j,t}$'s consistent with a given change in life expectancy. Furthermore it seems that what one wants to value is the D_j's. She suggests that it might be better to ask people to value a change in the conditional probability of death at various ages.

Life Shortening

The life shortening method of presenting mortality risks to respondents is similar to life expectancy except that it does not require a discussion of probabilities.

Figure 4-7
PROBABILITY OF SURVIVAL WITH AND WITHOUT THREAT
OF CANCER (FOR LIFE EXPECTANCY QUESTION)



The absence of probability from the discussion makes this approach easier to understand than the life expectancy approach. Also it is possible to use one chart to illustrate remaining life for people in every age group. This makes it easy to tailor the question to the endowment of each individual respondent. The remoteness of the contingent market product for many respondents remains a problem, however.

An example of the life shortening approach is as follows.

> Consider how many more years you can expect to live once live once you reach the age of 50. Of course, you would hope to live as healthy and as long a life as is possible. Please look now at Figure 4-8, which depicts in graphic form the national averages for remaining lifetime, expressed in years. Note for example that a 50 year old can look forward to 16 more years, etc.

Q. How much would you be willing to pay for a program that would extend your life by two years?

Lottery Wheel

The lottery wheel is the most graphic portrait of mortality experience developed so far. It is a device that involves the respondent in an activity that builds up an idea of a person's risk of death under varying conditions.

The prototype wheel is two feet in diameter and consists of a wooden arm spinning on a skate boardwheelbearing affixed to a sheet of plywood. Nails, equally spaced at the periphery, divide the circle into 90 segments. A piece of flexible plastic at the end of the arm provides Las Vegas-type noise and forces the arm to stop within a single segment (between two nails). Paper overlays depict a wide variety of pie charts that show age of death and health-disease distributions. The pie charts depict different size segments that correspond to different likelihoods of being in good health, having heart disease, etc., at various ages. The pie charts are constructed to reflect the probability distribution, the population within five year intervals beginning at each decade of life. A sample is shown in Figure 4-9.

Contingent market goods were constructed for testing in focus groups by depicting the mortality expectation of a 50 year old person with and without cancer risk. This is done by showing the actual expectations of the person in one ring of a pie chart, and the calculated expectations of death with cancer removed in another ring. Repeated spinning of the "wheel of death" gives the participant a sense of improved prospects in the absence of cancer. When the participant is adequately prepared, willingness to pay questions to get the without-cancer lottery are asked.

Testing of the lottery wheel in focus groups indicated that

it has a great deal of promise for future use in both mortality and morbidity contingent-valuation work.

Card Game

As probabilities become smaller, the probabilities generally become more difficlt for resopndents to interpret. Some people however have acquired a sense of small probabilities in connection with work or leisure or activities. People who play cards are examples of such people.

An example making a link between card games and probabilities encountered in health risks follows. Unexpected painless mortality from heart malfunction is a health risk that carries quantifiable probabilities for persons of given age, general health and personal characteristics. A contingent market can be established by proposing a card game to persons in various risk categories, with hands dealt from a deck in which the probability of heart malfunction corresponds to the propbability for people of their category. Respondents are then asked how much they would pay to reduce the number of heart malfunction cards in the deck.

4.5.6.2. Morbidity

Several different approaches were developed for posing contingent valuation questions on serious morbidilty. The approaches are discussed in this section.

Specific Disease 'Approach

In the specific disease approach, diseases are named, allowing for the possibility for semantic effects in the valuation of risk reduction. A bronchitis question is illustrated in the following question.

> Chronic bronchitis is an illness affecting about 3 percent of all adults in the United States. Bronchitis is an upper respiratory disease which causes coughing andchest pain. In addition to physical discomfort, many people with chronic bronchitis become discouraged and depressed about this illness. In addition to to cigarette smoking, air pollution is acause of chronicbronchitis and it also aggravates the condition. Treatment of chronic bronchitis with medicinesis helpful but tends to create side effects.

Figure 4-8
REMAINING YEARS OF LIFE AT VARIOUS AGES
(FOR LIFE SHORTENING QUESTION)

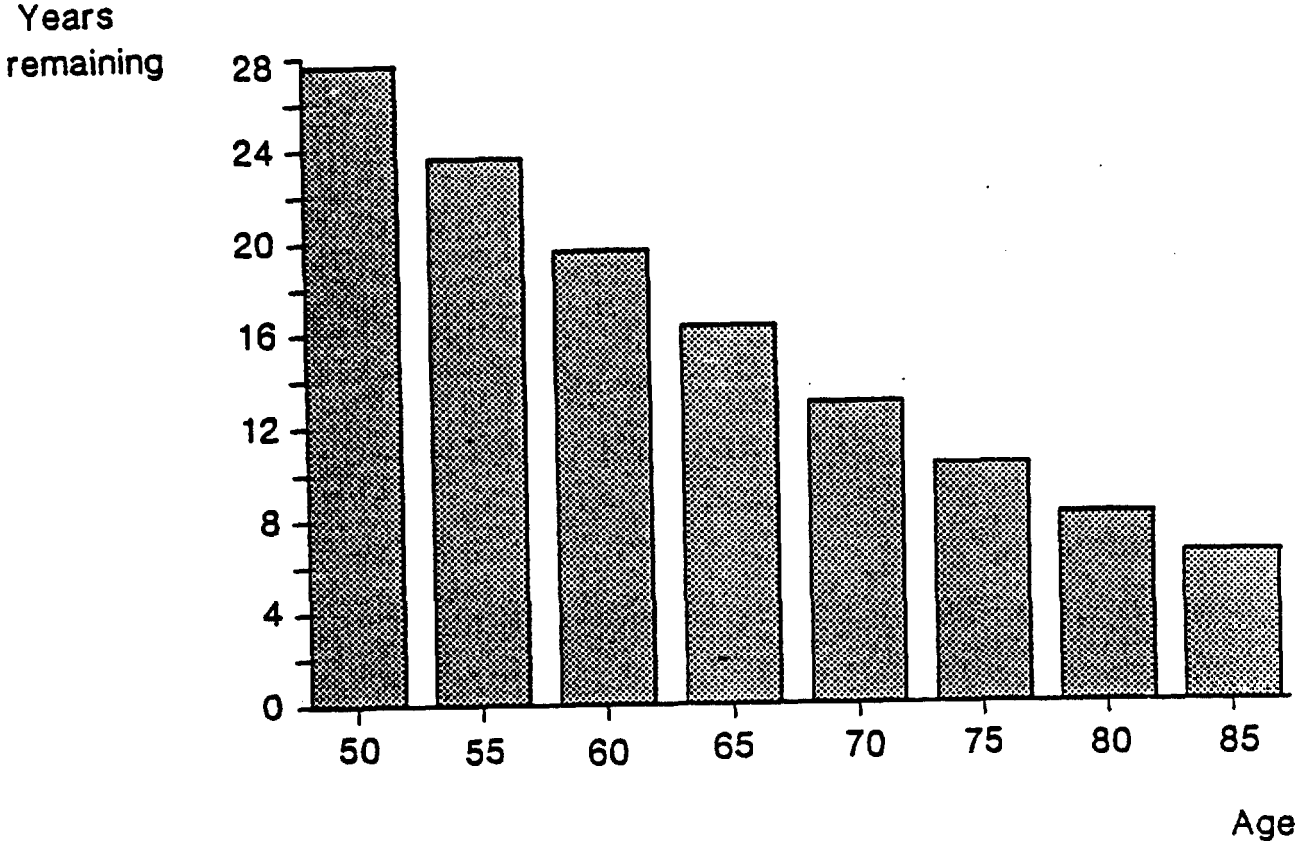
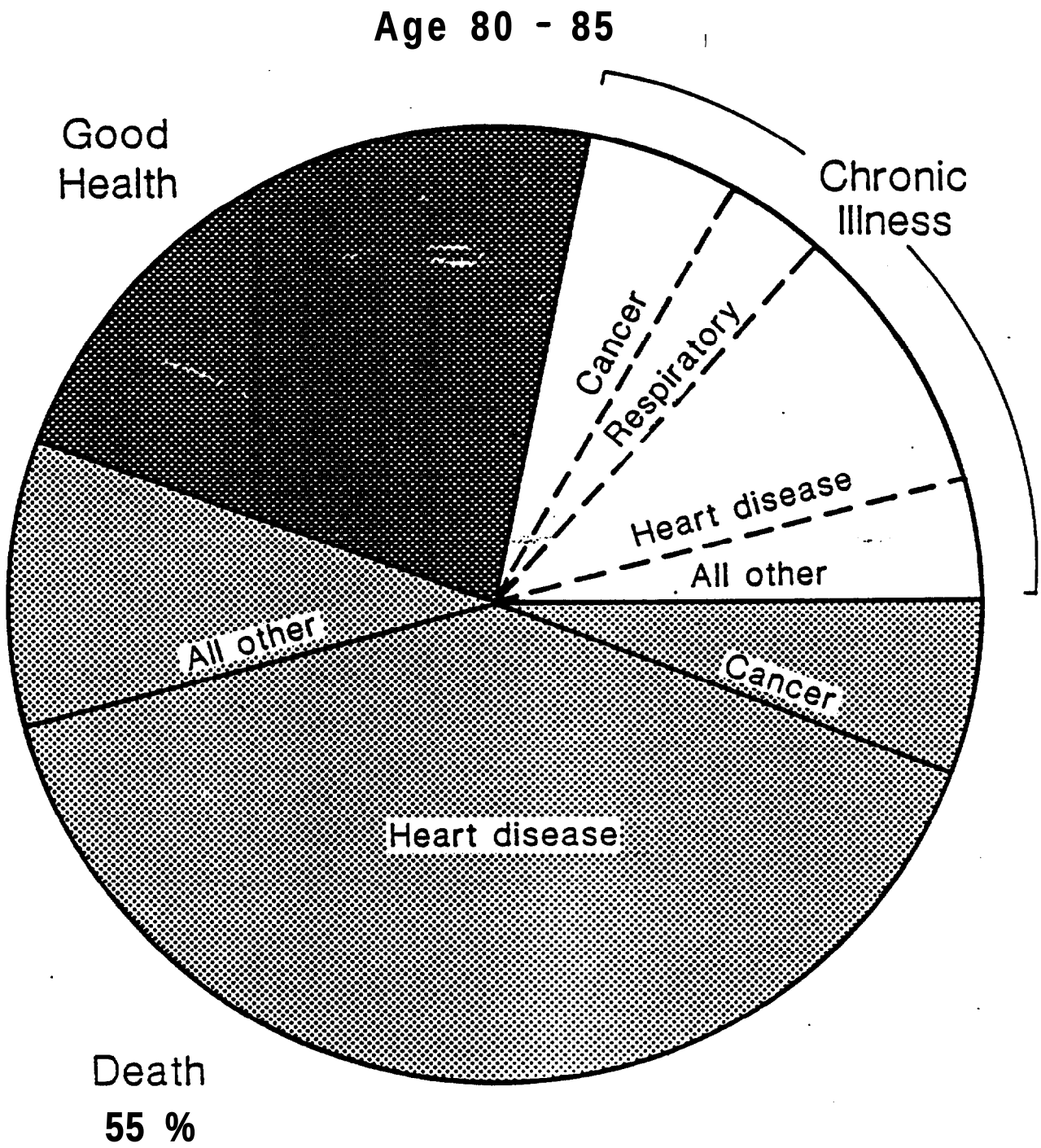


Figure 4-9
PIE CHART FOR MORTALITY LOTTERY WHEEL



How much would you be willing to pay per month in to eliminate the risk of bronchitis?

Aside from the semantic effect of mentioning a specific disease, a problem in this question is the precise amount of risk that is being eliminated in the contingent market.

The following question, concerning cancer, combined illness with substantial risk of death. The death risk was presented implicitly to the respondent by revealing the overall experience in the U.S. population.

> Chemicals in the environment, in the air, in water, and in some foods are believed to be significant cause of cnacer in the United States. These cancers include cancers of the lung, kidney and liver. Today about half of all cancer patients die of the disease and about half survive. A great many cancer patients, both those who die and thosewho survive, have to undergo- radiation, chemotherapy, or surgery, often in combin- ation, which formany is a highly uncomfortable and emotionally trying experience.
>
> How much per month would you be willing to pay to eliminate the risk of getting cancer of the lung, kidney, or liver or some other organ?

General references to the experiences of the entire U.S. population are limited by the fact that they do not give respondents the kind of graphic description of illness that assists them in judging the value of removing or lowering the risks they face. This health attribute and life path approaches, which follow, add the desired element of realism to the contingent market product.

Health Attribute Apporach

The health attribute approach focuses entirely on the effects of diseases and avoids naming the underlying causes. Semantic effects can be tested by listing the symptoms caused by a disease in one survey and actually naming the disease in another, comparable survey. An example of the health atrribute approach follows.

> Physical discomfort effects of illnesses include coughing, pain with each breath, and other effects. I

will ask about each effect separately. Each of these effects would continue for many years, unless the question says that is it for several months.

a.	Frequent, persistent coughing	$--m--e-- per month
b.	Chronic throat irritation	$-e--v--- per month
c.	Gripping pain with each breath	$a------- per month
d.	Itching and smarting of eyes	$-------- per month
e.	Frequent nausea, feeling of need to vomit for several days each week for several months	$-------- per month
f.	Whole body discomfort, feeling rotten all over for several days each week for several months	$-------- per month

It was discovered in focus group experiments that numerous questions in quick succession are not conducive to carefully considered answers. Instead, answers may become rather -mechanical unless broken up with intervening discussion and preparatory thinking on the part of the respondent. This consideration limits the number of bids that can accurately be obtained.

4.5.6.3. Life Path Approaches Combining Morbidity and Mortality

Life path approaches represent a progression towards the creation of a realistic setting in which respondents can relate to health problems that are either current, possible in the next few years, or in the distant future. The approach is to construct several parallel life paths with a number of common elements and ask contingent valuation questions on each. Respondents who might not be able to value an isolated event such as dying two years earlier in 40 years may well be able to express a preference for one life path over another and assign dollar values to the preference.

Both morbidity and mortality considerations are embodied in the life path scenarios. Consideration was given to measuring interactions between them and valufng tradeoffs. Scenarios were developed in terms of certain alternatives and in terms of uncertainty, as will be described in this section.

Certainty Scenarios

Table 4-2 shows three alternative life paths, characterized by either cancer, emphysema or heart attack. They differ substantially in the overall quality and length of life that is

Table 4-2. LIFE PATH SCENARIOS

Age	Cancer Scenario	Emphysema Scenario
50	Good Health	Good health
55		Symptoms (which probably began. earlier) become apparent: Loss of energy (e.g., climbing stairs tires you out; shortness of breath, difficulty in breathing. Breathing difficulties result in increasing work absences.
60	Relative good health but Symptoms become noticeably reduced from that at 50.	Symptoms become increasingly severe. Health deteriorates to the extent that early retirement is necessary.
65	Health reductions continue both with no serious illnesses. You continue able to do a full day's work, but you retire at age 65.	Lung deterioration reaches point where you intermittently must use a portable bottled oxygen supply to reduce breathing difficulties while walking.
70	Cancer symptoms become apparent, and chemotherapy is initiated. Side effects include nausea. You feel the need to vomit several days each week. There are periods of improved well being, but on other occasions you feel rotten for days at a time.	You become bedridden and require continuous bottled oxygen to reduce breathing difficulties.
74	Chemotherapy and side effects continue, but otherwise you lead a normal life.	Death due to heart failure.
76	Cancer spreads throughout your body and death occurs.	
78		

(Third scenario presented on next page)

Table 4-2 (continued)

Age	Heart Attack Scenario
50	Good health
55	
60	Relative good health but noticeably reduced from that at age 50.
65	Health reductions continue but with no serious illnesses. You continue able to do a full day's work, but retire at age 65.
70	Still no serious illnesses
74	
76	
78	Sudden and painless death occurs due to heart failure.

(End of Table 4-2)

offered. The example illustrates the certainty approach to life path analysis.

Respondents are asked to rank the life paths in order of desirability and express a willingness to pay to avoid the less preferred life paths. Focus group experience indicates that this is a promising method of obtaining values. It imparts reality to the contingent market alternatives that are offered.

Possibilities exist to tailor the scenarios for special purposes. Distinct symptom modules 'form the life path building blocks. A set of life paths can be built from the symptom sets and combined with different ages at death. The life paths can be ranked and values expressed relative to a base case path. The results could be used in policy analyses that detail the disease effects of illness by symptom and age of death more completely than at present, but they would also be **useable** in present state of the art policy evaluations.

Uncertainty Scenarios

The following survey segment substituted probabilities of obtaining the life paths for the certain alternatives of the previous questionnaire. A simple probability display device was used to convey the idea of risks and help the respondent make probabilistic choices.

The example below illustrates the questionnaire approach.

> Each of us faces an uncertain future concerning our health and length of life. Knowledge about health is increasing, however, and we are learning more about how we can influence our own prospects. Public health officials, are learning more about what of government policies can improve the health and life expectancy of the general population.
>
> We are very interested in your views about the value of health improvements. I would like to ask you some questions about a matter of importance to people- -how you feel about the uncertainties and risks to your future health.

The life path scenarios presented above in Table 4-2 would then be combined with a probability analysis to see how much people wold be willing to pay to reduce the risk of the more undesirable scenarios.

4.5.7. Implications

The proposal for the in-depth four module approach that has been developed in this section grew out of findings from focus group experiments. For example, early focus group work indirected respondents had difficulty grappling with life threatening illness in a short interview. It became apparent that a major experimental effort would be required to devise effective probabilistic contingent markets in health. Several experimental games were tested that may develop into useful approaches in future work.

Equally difficult was the task of getting respondents to think seriously about contingent payoffs defined far into the future. Younger respondents in particular found it was difficult to place any value in an extra year of life or health at age 70 or 75. Because certain benefits of environmental improvement are likely to be of this type, it will be particularly important to address the problem of deferred benefits in future work.

The role of the participant's own health endowment became the subject of thought during this early period. Two objectives became apparent. One was to have a standard, well defined contingent product for which all respondents would bid. The second was to make the contingent market as realistic as possible by relating it to the respondent's own experience. This eliminates the need for the respondents to try to imagine having a hypothetical endowment and then imagine hypothetical departures from that endowment.

The first module of the four module approach, health status, developed the methods required to establish the respondent's endowment, to tailor contingent market goods to the individual's own circumstances, and to start the respondent to think about health preferences that have usually not received much attention. The second module, defensive measures, investigates and records the activities that people take to avert illness or threats to life and health. These activities include health practices, changes in life style and also expenditures on market goods that contribute to health. Risk perception and risk behavior in the third module. Its purpose is to convey an understanding of probability that is adequate to understand and respond to questions that elicit the value of health improvements that are plausible results of environmental policy. The work of the first three modules is brought together in the fourth module, contingent valuation. Contingent market health products, realistically tailored to each respondent's health endowment, are formulated. Respondents are assited in thinking carefully about the value that these health products would have in their lives, and to express their willingness to pay for them. Program effects are presented in terms of alternatives that can be obtained with certainty, and also as alternatives that will occur

only with various stated probabilities.

Risk age, life shortening, life expectancy, and lottery of life approaches are used in constructing life path scenarios. Further research is necessary before the most effective approaches can be identified.

In life path scenarios, which are needed and promising, methods and information for relating to environmental effects needed to be developed. The visual approach is one effect on death rates. Even apart from the latency problem, a person with increased.exposure to pollutants faces a stream of altered life path prospects from different points in the future depending on when the disease is contracted. The problem exists when the probability of contraction of disease is independent between time periods and it also exists when there is a latency period, which merely complicates slightly the estimation of probabilities of when the disease will be contracted.

Future research needs to address two closely related concepts, as follows.

Level of Discrimination

Intuitively one would expect that individuals could value some risk reductions more meaningfully than others. For example the probability or risk of death could increase from almost zero to 1/6 (if one should choose to play Russian Roulette) or it could increase from 1.1/1,000,000 to 1.8/1,000,000 (odds perhaps associated with an increase in an environmental trace concentration of some toxic substance). Somewhere between these extremes, an average respondent likely would lose the ability to discriminate between one risk level and another. Future research would attempt to approximate this discrimination treshold.

Level of Complexity

There are other complexities in addition to discrimination which make it difficult to distinguish between and ultimately value one risk versus another. Pertinent information is helpful in this regard. Increased information beyond, some point, however, has less value and eventually is counterproductive.

Pertinent variables include:

Age specificity
(present age and age of death)

Disease specificity

Cause of death

Cause of the cause of death
(risk factors such as alcohol, obesity, air pollution)

Level of health or morbidity
(physical status, level of disability)

Thus, at one extreme, a respondent might be given virtually no information prior to being asked to value a change in health or death risk. At the other end very explicit life paths, tailored to the individual, could be provided. Future research should identify minimum information levels needed to obtain meaningful contingent valuations.